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HANDBOOK
TO THE
GEOLOGY
AND
NATURAL HISTORY
OF
NORTHUMBERLAND AND DURHAM.

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OUTLINES
OF THE
GEOLOGY
OF
NORTHUMBERLAND AND DURHAM.

BY

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"TURPE EST, IN PATRIA HABITARE ET PATRIAM IGNORARE."

(SECOND EDITION, AS REGARDS NORTHUMBERLAND.)

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PREFACE TO THE FIRST EDITION

("Outlines of the Geology of Northumberland").

I WAS led in the first instance to prepare this little book by the requirements of the class of Geological Surveying which I have for some years had the honour of conducting in the Newcastle College of Physical Science. Most of the work in connexion with this class lay necessarily in Northumberland, and the want of any general geological description of the County to which students could be referred for leading facts has been much felt by me. At the same time, such an outline should be acceptable to the miner and—although it is not written in the popular style supposed to be relished by the general reader—to the tourists and sportsmen of our Border County.

G. A. LEBOUR.

College of Physical Science,
October, 1878.

PREFACE TO THE SECOND EDITION

("OUTLINES OF THE GEOLOGY OF NORTHUMBERLAND AND DURHAM").

ALL in this little book that refers to Durham and Cleveland is new. It is a second edition as regards Northumberland only, and even in this portion much has been added, corrected, and re-written. The first edition (" Outlines of the Geology of Northumberland ") contained no illustrations. The present one is illustrated by plates prepared especially for it and by woodcuts. The latter have all appeared from time to time in professional papers published by the author in the Transactions of the *North of England Institute of Mining and Mechanical Engineers*, the *Geologists' Association*, and the *Geological Society of London.* His sincere thanks are due to the Councils of these Societies for the ready loan of these cuts. He also takes this opportunity of acknowledging the benefit which he has derived from information and suggestions given and made to him by Professors J. H. MERIVALE and BEDSON, Messrs. J. B. ATKINSON, M. WALTON BROWN, M.

HECKELS, and many others whose names, he trusts, will be found duly referred to in the body of the work. It has been very gratifying to him to find it necessary to make use of the original geological work of so many former students of this College—the best proof that its teaching is bearing fruit.

The Durham College of Science,
Newcastle-upon-Tyne,
15 *October*, 1886.

INTRODUCTION.

THE first portion of this Handbook consists of the Second Edition of my little book on the Geology of Northumberland and Durham as it appeared in 1886, together with a few newly-printed pages of supplementary matter bringing it up to date. The rest is a compilation from published lists of materials for a Natural History of the two Northern Counties, and contains absolutely no original matter of my own (unless involuntary errors be accounted as such).

To those who wish to enter more fully into the subjects treated of in the following pages, the Transactions of Tyneside and Berwickshire Field Clubs and of the Natural History Society of Northumberland and Durham are recommended as a veritable mine of valuable information. To these I would add the very useful yearly Bibliographical lists relating to North Country Natural History and Geology which the "Naturalist" has contained of late years.

Best of all, I would ask scientific visitors to Newcastle to examine its fine Natural History Museum carefully. In it they will find much of the material from which the descriptions and enumerations in the works above mentioned have been drawn up—the collections of Messrs. John and Albany Hancock, Joshuah Alder, Hutton, Atthey, Winch, and many others whose names must always be associated with a very remarkable epoch in the growth of Natural Science in this country.

I wish especially to thank Mr. R. Howse, Mr. W. Topley, F.R.S., Mr. W. Dinning, and Mr. Faraday Spence, for the help which they have given me.

THE EDITOR.

September, 1889.

TABLE OF CONTENTS.

CHAPTER PAGE

I.—List of Formations occurring in Northumberland and Durham 1

II.—The Lie of the Rocks 3

III.—Recent and Sub-Recent Deposits 7

IV.—Drift Deposits 21

V.—The Trias and Permian 28

VI.—The Coal-Measures 39

VII.—The Gannister and Millstone Grit Series 54

VIII.—The Bernician Rocks 58

IX.—The Tuedian and Basement Beds 73

Comparative Table of Carboniferous Divisions 81

X.—The Silurian Rocks 82

XI.—Igneous Rocks: Dykes 84

XII.—Igneous Rocks (*continued*)—The Great Whin Sill 92

XIII.—Igneous Rocks (*continued*)—The Cheviots, etc. 102

XIV.—Materials for a Palæontology of Northumberland 108

Remarks on the Lists of Fossils 128

XV.—Faults and Veins... 132

XVI.—Summary of the Geological History of Northumberland and Durham 138

XVII.—The Cleveland Ironstone District... ... 142

Appendix:—Mr. H. Miller's Classification of the Lower Carboniferous Rocks of the Northumbrian Type 146

ndex of Persons and Places 149

EXPLANATION OF THE PLATES

PLATE I.—Sketch Geological Map of Northumberland and Durham,

PLATE II.—FIG. 1.—Section from Makendon to the Tees.

„ FIG. 2.—Section showing the Lie of the Coal-Measures from the Northern to the Southern extremity of the Great Northern Coalfield (after J. B. SIMPSON)

PLATE III.—FIG. 1.—Section showing Junction between the Yellow Sands and the overlying rocks, as seen at Claxheugh in 1884.

„ FIG. 2.—Permian Cliff at Tynemouth.

„ FIG. 3.—Breccia Gashes in the Permian Magnesian Limestone at Marsden.

PLATE IV.—FIG. 1.—Section from the Mouth of the Tees to the Cleveland Hills, along the Coast.

„ FIG. 2.—Section showing Faulted Boundary between the Cheviot Porphyrites and the Tuedian.

„ FIG. 3.—Section at the Ridlees, showing Unfaulted Junction between the Tuedian Beds and the Cheviot Porphyrites.

PLATE V.—Sketch Map, showing the Outcrop of the Cleveland Ironstone South of the Tees (after Tate and Blake).

HANDBOOK OF THE GEOLOGY OF NORTHUMBERLAND AND DURHAM.

CHAPTER I.

List of Formations occurring in Northumberland and Durham.

Proceeding downwards in the geological scale—that is to say, from those deposits which are being formed at the present day under our very eyes, gradually to those rocks the origin of which dates from the earliest times—these notes will be conveniently grouped under the following heads:—

RECENT DEPOSITS

(or such as are still forming).

Rainwash	Land and freshwater.
Alluvium	
Peat	
Blowing sand	Æolian.
Tidal deposits	Marine and estuarine.

SUB-RECENT DEPOSITS

(or such as are of the same character as the Recent Deposits, but are no longer forming).

Old lake deposits	Land and freshwater.
Old river gravels and sands ...	
Brick-earths and clays	
Raised beaches...	Æolian and marine.

DRIFT DEPOSITS.

Kaimes or Åsar	Marine.
Moor gravels	Glacial, land.
Moraine heaps	
Upper drift sands	
Upper drift gravels	
Reassorted boulder clay... ...	
Upper boulder clay	Glacial, marine, and fresh-water.
Lower drift sands and gravels	
Lower boulder clay	

(The whole of the Tertiary and all the Secondary rocks newer than the Trias are absent.)

TRIAS AND PERMIAN.

Red sandstones...	Marine, chiefly land-locked seas.
Red sandstones and marl ...	
Marly red sandstones with salt, etc.	
Magnesian limestone	Marine.
Marl slate	
Yellow sands.	

UPPER CARBONIFEROUS

(or Coal Measures).

Coal-measures proper	Marine, land, and freshwater.
Gannister beds	
Millstone grit	

LOWER CARBONIFEROUS

(or Carboniferous Limestone and Calciferous Sandstone series).

Bernician series	Marine, land, and freshwater.
Tuedian and Basement beds...	

SILURIAN.

Clay-slate and grits	Marine.

IGNEOUS ROCKS.

Basalt (Dolerite), porphyritic traps, granite, etc.

CHAPTER II.

THE LIE OF THE ROCKS.

THE general Geology of Northumberland and Durham is simple in its broad features. The beds, as a whole, slope to the sea, so that any one travelling from the coast to the Scottish border, across the country, would be always encountering older and older formations. As he trudged along he might gradually pass over Triassic, Permian, Coal-measure, Millstone Grit, Carboniferous Limestone or Bernician, Tuedian, and Silurian rocks. The direction of this general dip lies between South-East and and East, so that the *strike* of the rocks runs about South-West and North-East.

But, looked at more closely, much of this simplicity of structure is found to be obscured. A few undulations in the strata have here and there altered their course, which has been still more largely interfered with by a few long lines of dislocation or faults. Then masses of igneous rocks have been injected through and amongst the originally undisturbed beds, sometimes shooting along the lines of dislocation and filling them up, or squeezing in between the strata along the planes of bedding, or at other times rising bodily as great bosses of consolidated trap, and upheaving the deposits around them. From these various causes the aforesaid simple geological structure of the country has been modified not a little, and, in order to arrive at a fair understanding of their effects, it will perhaps be best to enumerate the principal disturbances in their chronological order.

The first of which we have any record occurred before the deposition of the Carboniferous rocks, and probably when the sea far away was teeming with Upper Silurian life. The older muddy and sandy sea-bottoms of Lower Silurian age lay flat and undisturbed when the Cheviot volcanoes first began to emit the lavas which we now find hardened into ash and porphyrite. The older Silurians were thus tilted upon end—probably not all at once, but by continually repeated uprisings.* The Old Red Sandstone times supervened, and the Cheviot traps were stony and cold as they are now, although still with a tendency to occasional movement, when, towards the end of that period, the upturned edges of the Silurians having been planed down by denudation, the lower Carboniferous deposits were gradually accumulated around the flanks of the old fire hills, abrading their sides and incorporating their fragments with Silurian and Old Red sands. So far as we know no important event took place during the leisurely deposition of the Carboniferous series, which, as it accumulated, crept steadily up the sides of the Cheviot range—without, however, entirely covering it—until near the close of that age. Then there is reason to believe that Northumberland became once more a focus of volcanic agency. The old Cheviot centre heaved again, and broke the beds around it in sundry places, causing dislocations or faults more or less parallel to its contour, with smaller radiating ones in its immediate neighbourhood. A great sheet of lava (now basalt) was injected between, and to some extent through—the Lower Carboniferous beds, whilst a few of the radiating faults or fissures already mentioned were filled with similar lava, some spreading over the surface and others failing to reach it. These events destroyed the horizontality of the Carboniferous beds. Most of them were now dipping towards what is now the sea, the dips decreasing in amount as they approached it. In the North they were folded and contorted much more than in the South, but probably at or about the same period. One long fold, however, was brought about in South Northumberland from the Cheviot to the Tyne, about where Corbridge now stands. This was a long low-arched saddleback or anticlinal, the result of which was that only to the East of it did the beds still dip steadily to the East, whereas on the other side they either lay flat or gently rolling, as they still do in great part of Teesdale, Weardale, Tynedale, Redesdale, and Coquetdale. In South Durham, between Barnard Castle and Bishop Auckland, an East and West anticlinal fold had also been formed, the effect of which was to set the beds on its northern slope dipping towards Sunderland. Then came a time of submersion, during which the edges of the now disturbed Carboniferous rocks were planed down, and denudation was at work once more. On these eroded beds the Permian sands and limestone were next deposited, flat and undulating, much as we find them now. Probably Cheviot still acted from time to time as a centre of upheaval, and helped to cause minor disturbances in the Border districts; but certainly, at some time after the deposition and consolidation of the Permian rocks, another great series of dislocations was brought about, this time affecting the Southern parts of the region in a greater degree than the more Northern. Two of these lines of dislocation were especially noticeable in their effects. One, with a varying shift, threw down the beds to the North of Newcastle, so that the Permian limestone was brought down side by side with the Coal-measures. This is the so-called Ninety-Fathom Dyke, a fault which runs from Cullercoats, by Denton, to Greenside and Whittonstall, often much exceeding ninety fathoms in throw, but dying away to nothing a little to the West of Minsteracres. The other fault—taking up the running, as it were, where the first leaves off—begins a little to the South of Corbridge, and runs almost due West parallel to the Tyne right into Cumberland. This is the Stublick Dyke. It throws the beds down to the North, so as to bring the Coal-measures side by side with the base of the Millstone Grit; but it has another and still greater effect, for it causes the beds North of it to dip down sharply towards itself. The result of this alteration of dip, both in amount and direction, on the downthrow side of the Stublick Dyke has been twofold—first, it has (added to the long anticlinal axis already noticed) altered the strike for several miles from its course, so that all the beds as they approach the Corbridge fold from the North and East instantly strike due West; and, secondly, it has allowed the preservation on its Northern side of a number of small true Coal-measure coal-fields, which (owing to the high dip near the fault) comprise many more seams than their limited areas would lead one to suppose. As usual with large faults, these and others parallel to them are accompanied by a number of transverse or radiating dislocations, with minor throws. In later times, probably ranging to the Middle Tertiary, more faults were formed, but not of so much importance, and these, together with older ones (many Pre-Permian), were again filled with molten basalt from below.

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* Another reading of the events of this time would have us regard the Cheviot eruptive mass as poured *over* the already contorted and denuded Silurian rocks, and there is much to be said for this view, which, however, does not affect the chronology given above.

The above are the main disturbances affecting the geological structure of Northumberland and Durham in its chief features. Several large faults in the North of the former county are not yet sufficiently understood to be included in any general statement of this kind, but will be noticed in the chapter on "Faults." *

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* For instance, a great East and West Fault, running from the Coast to a little to the South of Lowick, appears to repeat the entire Bernician series.

CHAPTER III.

RECENT AND SUB-RECENT DEPOSITS.

RAINWASH.—According as the various rocks forming the country are more or less exposed to the effects of weather, and according as their texture and structure render them more or less liable to disintegration, solution, or splintering, so is the thickness of the deposit or surface-accumulation known as rainwash. Many varieties of rainwash occur in Northumberland and Durham.

Surfaces of true and re-assorted boulder clay, when exposed—as in numberless railway cuttings—to the action of rain, become capped by a sandy and slightly gravelly rainwash, the clay being gradually washed away. Exposed sandstone districts—such as occur sparingly over the Coal-measure areas, but very abundantly in the Western and Northern parts of the two counties, afford a considerable quantity of sandy rainwash, the distribution of which is extremely irregular. Deposits of this kind, often several feet in thickness, are well seen among the crags formed by the Harbottle grits, especially at a place called The Swire, near the village of Harbottle, on the South side of the Coquet.

Shales are seldom sufficiently exposed to give rise to much rainwash.

That great mass of igneous rocks, which may conveniently be grouped together as the Cheviot Traps, gives rise to three distinct deposits, which—being all due to weathering—may properly be noted here. These are:—(*a*) Clays resulting from the decomposition of the felspar of the Trap, and forming more or less pure masses of "kaolin" of limited extent, and usually filling vertical fissures in the rock. I have seen several china-clay veins of this kind in the hillsides between the Alwin and the Usway. (*b*) A dark brown or reddish earth, forming taluses towards the base of the flanks of the hills. This earth is chiefly observable where the Trap has a tendency to spheroidal structure, and weathers in concentric coats. An exactly similar product is very common in connexion with the ordinary whin dykes of the country, and, much less frequently, associated with the Great Whin Sill. A white earth, occasionally granular, holding a position somewhat between the white clay and the brown earth, is in some cases all that the action of rain water, continued for a great length of time, has left of the hard bluish-green basalt of some whin dykes. This is notably the case in a dyke which formed for many years the Eastern boundary of the Plashetts coal workings. Here the decomposed mass was so white and soft that it was generally described as a dyke of "plaster." (*c*) Screes, forming a loose uncemented breccia, due indirectly to rain and directly to frost. These form long shoots and taluses, more especially where the structure of the Trap is more or less massive, or sub-columnar, but not spheroidal. The fragments of which this deposit is formed are sharply angular and generally conchoidal. The shoots of these sharp-edged stones are well known locally by the name of "glitters" or "glidders," and are beautifully shown in many parts of the Cheviots, but perhaps nowhere better than in the valley of the little river Alwin, above Alwinton.

The limestones do not give rise to true rainwash, but they are acted on chemically by rain water in a powerful manner, and part of their substance—abstracted from them by the carbonic acid with which the rain is charged—is frequently re-deposited by springs in the form of calcareous tuff or "travertine." As a rule, these deposits are of small importance in this district; but in a few cases—as a little to the East of Dykenook, near Elsdon; a little to the North and East of Horsley, in Redesdale, etc.,—they cover ground some acres in extent.

Allied to the calc-tuffs, and, like them, due indirectly to the chemical action of rain water, are certain thin beds of conglomerate, which often occur in almost all gravelly deposits, notably in the fine section of drift gravel on the North bank of the Wansbeck above Morpeth, just below the mouth of the Font. Here the pebbles of the ancient gravel are cemented together in a friable calcareous and ferruginous matrix, which is probably still in course of formation.

Alluvium.—Under this head are included all those low-lying spreads of loam, sand, or gravel which form the lowest ground of the river valleys which are still flooded from time to time, or which, although they may have for years kept above water, may yet conceivably still be flooded in unusual seasons. Such are most of the "haughs" of Northumberland. Similar low flats skirting the margin of the small lakes of the county are to be classed as alluvium also, although in composition they may be distinct from the river accumulations. The latter necessarily consist partly of the rainwash before described and partly of matter directly torn from their banks by the rivers themselves and by their tributary burns. The former are usually to a great extent organic in their origin, and are more or less allied to the peat bogs, of which mention will presently be made.

The alluvia of all rivers necessarily vary in character according to the nature of the rocks forming each basin of catchment. The mixture of Drift materials with fragments of the true local subsoil prevent the evidence of the origin of the alluvial deposits in this part of England being absolutely good, more particularly in the lower reaches of the rivers, but yet sufficient distinctions are obvious to an attentive observer. Thus:—

The Till and Beamish deposits and those of the Coquet are loaded with evidence of their Cheviot origin, the fragments of porphyritic rocks being far too numerous to be attributable to the contents of the Drift alone. The upper Coquet, especially, marks its course by haughs of dark brown porphyritic loam or stretches of gravel, almost every pebble of which is of Cheviot origin, sometimes containing or consisting of chalcedony (agate) and jasper.

High up the Redewater, near Lumsdon and Ramshope, the porphyritic pebbles are again to be found, but they soon give place to very sandy loams, often of considerable depth and great breadth, as between Otterburn and Monkridge.*

The North Tyne haughs are free from porphyritic pebbles, except such stray ones as may be derived from Drift deposits. Here the true alluvia are not very largely developed, and consist of sandy loams and gravels, in which sandstone, limestone, and some basalt (from the Whin Sill principally) are the chief constituents.

The South Tyne alluvia are easily distinguished from those of the North Tyne, not, however, because of any marked difference in the geology of the country watered by the former stream, but on account of the great mass of old gravels through which it cuts its way. Old gravels, the constituent pebbles of which belong to the Western side of the Penine chain, and probably also in a large degree to the Scottish lowlands. The Wear deposits similarly mixed materials along its banks, and for the same reason.

The Tyne proper naturally partakes in its deposits of both North and South Tyne types, and in its tidal part is marked by loams so argillaceous as to be used for brickmaking, although they differ slightly from the brick-earths proper.

The Wansbeck in its upper portion is, considering its small size, a great alluvium-making stream, as may be seen below Wallington and near Angerton. Lower down old gravels again add their already rounded pebbles from various parts to the strictly local alluvia from the near West.

The Derwent, except at its mouth, where it blends its delta with the great haughs of the Tyne, is not an alluvium-making river.

Peat.—This is, in the high grounds of Northumberland and Durham, the most universally spread of the recent deposits, and had not the more ancient fuels been fortunately also a feature of these counties, its inhabitants could well have had recourse to this newer material—as, indeed, they may yet some day have to do. Although essentially of the same vegetable nature, it is yet convenient to divide the peat of the country into two kinds, the *moor-peat* and the *bog-peat.* The moor-peat is naturally more widely distributed than the other. It clothes to the very summit the steep round-topped hills of the Cheviot range, where it forms the "moss hags" so disagreeable to the pedestrian in these mountains; and in the uncultivated parts of the rest of the region it is found on the tail-side of every crag, and forms the chief covering of the country at every level. It consists of a spongy mass of sphagnum moss, often resting on a layer of whitish or yellowish sandy clay passing into marl. Where this impermeable bed lies in a depression, the overlying peat assumes the character of a bog. This bog-peat generally lies flat, or nearly so, immediately over the depression, and that part of it is the true bog. In most cases, however, there is an outlet to the bog—sometimes more than one—for though ordinary lakes with two outlets do not exist, yet peat lakes of this description are common enough. For some distance the bog overflows along the outlet or outlets, and that part of it which thus dips away from the bog proper is aptly called the "flow" of the bog. Well-defined bogs and flows are very abundant in Western Northumberland and Durham—as, for instance, in the neighbourhood of Burnt Divot, a wild district between the South Tyne and the Irthing, not far from Haltwhistle; a little further North, about Cairnglastenhope*; to the North of Darden Lough, between Elsdon and the Simonside Hills; and in many other places of the same wild type.

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* See a note "On the Jaspers found in Ramshope Burn." by Mr. James Thomson, of Shawdon.—*Proceedings of the Berwickshire Naturalists' Club*, Vol. IX. (1882), p. 536.

Blowing Sand.—The wind-accumulations of sand which go by this name are, of course, limited to the coast line, and, in Northumberland, although very frequently met with, they fortunately cover no great extent of ground, Blowing sand is best exhibited, perhaps, along the coast from Berwick to Bamborough, and in Holy Island, about Alnmouth, and in a lesser degree wherever else the coast line is not bounded by rocky cliffs, as along the sands at Whitley and Tynemouth. The width of the "links" is in no case very considerable.

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* The author has a lively recollection of an hour spent with his pony breast deep in one of the most treacherous bogs in this inhospitable region. He was also present when a brother geologist met with a similar accident in the ominously named "Bloody Moss," close to Winter's gibbet, between Knowes Gate and Elsdon.

Tidal Deposits.—These, being limited in extent to the space between high and low water mark, are easily defined. To them belong the muds of the lower Tyne, as at Jarrow Slake (where the mineral Jarrowite was first found), of Blyth, and of Teesmouth, the great sand flats of Budle and Beal, Alnmouth, Whitley, Tynemouth, South Shields, etc., and the coarse pebble and boulder beds accumulating more or less at all the rocky points of the coast, as at St. Mary's Island, Howick, or Whitburn.

SUB-RECENT DEPOSITS.

These deposits are, to a great extent, of the same nature and character as the Recent ones, from which, indeed, they differ only in that—instead of being still in process of formation—they are now, for the most part, undergoing destruction —slow or rapid, as the case may be.

Peat Marls and Clays.—These are the whitish or yellow clays which have already been spoken of as frequently underlying the Peat. They are simply ancient rainwashes, preserved by vegetation and considerably altered by the constant layer of water which they support. They are often marly, and, when so, sometimes contain remains of land and freshwater shells, all of living species.* There is a strict analogy between these peat-marls and clays and the "thills" or "underclays" of many coals.

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* "History of Alnwick," by G. Tate, F.G.S., 1869, p. 468. See also "A New Flora of Northumberland and Durham," by G. Tate; Chap. I., Geology.—*Natural History Transactions of Northumberland and Durham*, Vol. II. (1868), p. 23.

Old Peat.—Under this head must come the lower part of most of the thickest peat-mosses of the country in which the remains of mammalia no longer inhabiting Britain have been found:—

Cervus alces, the Moose, at Chirdon Burn (North Tyne).
Cervus elaphus, the Red Deer, at a number of places.
Megaceros Hibernicus, the Great Elk, near to Cawledge Saw Mill, in the Alnwick district.
Bos primigenius, at Adderstone.
Bos longifrons.
And the Wild Boar, at Middleton, near Wooler.*

Remains of the Beaver *(Castor Fiber)* have been found in Roxburghshire.†

Bones of this kind have been seldom met with, however—probably because they have been so little sought after—but common throughout the peat districts are the buried stems and branches of trees where now no higher growth than that of the Ling is found. The largest and thickest stems known to me are to be seen in great numbers in the thick moorland peat capping the heathery fells immediately to the South of Shilburnhaugh, on the South side of the upper North Tyne, in the fork between that river and the Whickhope Burn.

Older than many of these ancient turbaries, probably, are some beds of peat which have been observed on the South side of the Tyne (at South Shields) lying beneath twelve feet of brick-earth,‡ and near the Redheugh Bridge in a similar position, and which doubtless extended, or still extend, into Northumberland. Old, also, are the peat deposits which have sunk below the sea level on the sea-shore, and now appear to us in the guise of so-called "submerged forests," such as are seen at North Sunderland, Newton, Howick, Whitburn,* and, best of all, at West Hartlepool.

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* Tate, *op. jam. cit.*, p. 468.
J. P. Selby, *Proc. Berw. Club*, Vol. III., p. 45 (1857).
R. Howse, "Notes on the Fossil Remains of some Recent and Extinct Mammalia in the Counties of Northumberland and Durham."—*Tyneside Nat. Field Club Trans.*, Vol. V. (1860-62), p. 111.
N.B.—These remains are also found in the peat-marls occasionally.

† See Note by Dr. Wilson, *Proc. Berw. Club*, Vol. IV. (1858-59), p. 76.

‡ Howse and Kirkby, "Synopsis of the Geology of Durham and Northumberland" (1863), p. 4.

Older still is the peat which, having once been submerged in the same manner, is now to be seen at the base of a raised beach, some feet above hige-water mark, near the North-Eastern Beacon of Holy Island.†

It is not everywhere possible to distinguish between the traces of old lakes and those of ancient bogs. Such traces are, however, abundant in Northumberland and Durham. They are not only easily known by their clear lake features, flat bottoms, and enclosing rising ground, but they are often marked by the name either of the hollows themselves or of houses or places standing by them. The frequent occurrence of such names as "Lough House," or "The Lough," where no lake or tarn now exists, is found almost invariably to denote the positions of former sheets of water. As a rule, it may be said that where a river or burn runs through the peat basin, we have the remains of a lake or lough; where the river or burn only runs *from* the basin, and not into it also, then we have to do with an old bog merely. The first case is well exemplified in the old lake of Prestwick Carr, near Ponteland—which, although its drying up was artificially completed, is distinctly entitled to be looked upon as an old lake—through which the Pont runs, and of Middleton, near Angerton, in the Wansbeck Valley. Corbridge has sometimes been regarded as standing on the site of an ancient lake, but this view has recently been ably disproved by Mr. G. W. Bulman.* A less doubtful case is that of a great portion of the Till Valley, in the neighbourhood of Flodden. The old bogs are much the commoner type, and are met with in all parts of the country, especially in the Western moors where recent bogs still obtain, as in the areas between the Irthing and the North Tyne, between the Redewater and the Coquet, etc., etc. A small old-lake basin, about a mile and a half to the North of Tarset Station, is worth mentioning from the fact that its floor is composed of a layer of very fine white unctuous clay, very like pipe clay.

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* See Tate in Johnston's "Natural History of the Eastern Borders," p. 313 (1853).

See Dr. W. Y. Veitch "On the Raised Beaches on the North-East Coast of Yorkshire," *Proc. Yorksh. Geol. and Poly. Soc.*, New Series, Vol. VIII. (1883), p. 221. This paper contains a description of this sunken forest.

† My friend and former colleague, Mr. W. Gunn, F.G.S., of H.M. Geological Survey, though he admits the existence of raised beaches on Holy Island, yet entirely declines to regard the gravel and sand lying upon peat at this spot as belonging to this category. I have revisited the place, however, and could find no evidence against the view stated above, which I, therefore, will allow to stand for what it may be worth.

Old River Gravels and Sands.—These are merely the alluvia left by the rivers which are still flowing, but at a height so much above the highest possible floods that the evidence that they were deposited when the "thalweg" was higher than at present is complete. In consequence, however, of much of the Drift of the country consisting of pebbly deposits from which these old river-gravels were often derived, much difficulty frequently arises in attempting to distinguish the one set of deposits from the other. Where the gravels are clearly terraced, we may conclude that they are river-gravels. Nowhere are such terraces better shown than on the flanks of the South Tyne Valley, from Warden Hill to Haydon Bridge and Haltwhistle. Step-like terraces of coarse gravel are there seen rising tier upon tier on both sides of the river, sometimes keeping separate courses for considerable distances, but oftener merging here and there insensibly one into the other. These terraces can be traced as high as the 300 feet contour line, and even higher, becoming less perfect in form as they increase in altitude. Above that limit the gravels continue in many places, but they are then no longer sorted and disposed in long lines by the old river. They belong to the mass of Drift gravel with which the pre-glacial valley was filled. In the Wansbeck and Wear Valleys we have a similar double series of gravels—Drift and River—with the additional difficulty that the latter are seldom distinctly terraced. Any line of division between the two, therefore, must be extremely doubtful. Along some parts of the Coquet's course terraces of old river-gravels may be distinguished, but they do not attain a high level. The same may be said of the Aln.

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* "On a Hypothetical Lake."—*Household Magazine* (1884).

In some cases the presence of old river-gravels enables us to follow former courses of rivers long since abandoned by them. This has been shown to be the case to the West of Haltwhistle. Here a valley of considerable breadth, and containing gravel terraces quite out of proportion with the little burn flowing along it, runs without obstacle from the Tyne to the Irthing. Mr. D. Burns, F.G.S., therefore rightly concludes that the Irthing in days immediately following the glacial epoch formed these terraces and ran Eastward into the Tyne instead of Westward into the Eden.*

Brick-earths and Clays.—Under this heading are included here only such of the brick-earths as can be referred to river action. On a large scale these are almost confined to the valley of the Tyne proper, and to that of the Till. They are distinctly seen to be of two ages. The youngest—newer by far than the old river-gravels—are the old loams which form the upper—unflooded—haughs on the South side of the Tyne between the Team and the Derwent. They are largely worked for brickmaking, and, on the Gateshead side of the Redheugh Bridge—interbedded with them—hazel nuts, etc., have been found by Mr. W. Dinning. These deposits often lie at a lower levels than the rivers now occupying the valleys in which they occur. Thus, quite recently (in the latter part of 1885), such beds were dug into at Wallsend, in which, at a depth of twenty-five feet beneath the bottom of the Tyne, a fine series of bones—similar to those found in some of the peat bogs already referred to—was collected by Mr. G. Shaw. The find comprised remains of *Bos longifrons*, Bison, Red Deer, and others not yet determined.†

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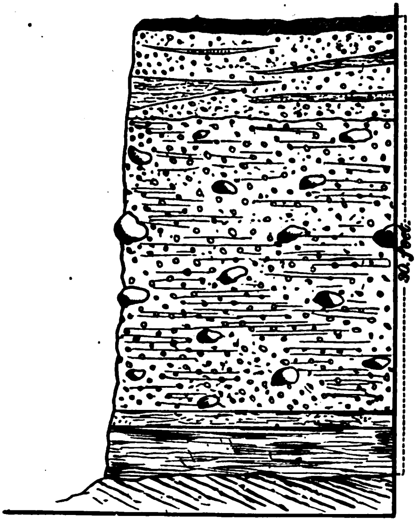
* *Annual Report of the Northumberland Union of Mechanics' Institute.* Newcastle (1875), p. 17.

† This collection is preserved in the Durham College of Science, to which it was presented by Mr. Shaw.

The older beds of this kind are to be found in the fork between the North Tyne and the Tyne proper, near Acomb. Here the upper flat on which the Acomb Colliery stands, between the St. John Lee hill and the two rivers, is an old river-gravel haugh of very clear origin. Immediately below the gravel, however, but still considerably above the present river level, is worked for rough pottery purposes a very finely bedded clayey loam, very similar in many respects to the "warp" of the Vale of York. The laminæ are extremely thin, and so coherent and supple that thin hand-specimens can be folded and rolled up like pieces of cloth. This "warp" has a very lacustrine appearance, but, as it is found at the junction of the two minor valleys of the North and South Tyne and at the head of the great Tyne Valley, and as no remains indicate a lake-deposit, it may be safer to look upon it as an old river-loam deposited in a kind of backwater where ex-

FIG. 1.—*Section of the Clay Pit at Acomb.*



tremely slow and undisturbed deposition was possible. This potter's earth is necessarily older than the old river-gravel beneath which it lies. Its colour is brown.

Many of the other clays used for tile-making, etc., in Northumberland and Durham, belong to the Drift.

Raised Beaches.—Few genuine raised beaches have been noted on the Northumbrian coast. Some doubtless remain to be discovered. I am at present aware of two only. Of these one is to be seen on the coast about half a mile to the North of the mouth of the Wansbeck, between it and Newbiggin-by-the-Sea. It is but fair, however, to mention that the Rev. Mr. Howchin, who has devoted much time and trouble to the study of this district, regards this not as a raised beach but as an old river bed. He describes it as—"The section of a river bed in the cliffs, about a hundred yards wide, and occupying the same position of juncture between the stone and clay which is the case with the existing river a short distance from its mouth. It probably possessed two outlets at one time; the present one, being the nearest and most direct, would ultimately drain off all the water, leaving the other outlet choked and dry."

"It is worthy of note that this ancient river bed is situated above high water mark. This may be the result either of a subsequent elevation of the land, or, what is more likely to be the case, the encroachments of the sea have eaten away so much of the lower reaches that it shows the bed of the river as it once existed at some distance up stream."* Without attempting to throw any doubt on Mr. Howchin's ingenious and legitimate hypothesis, I may be allowed to remark that several visits to the spot have failed to yield me any evidence incompatible with the more natural supposition that the deposits in question are a raised beach. Some evidence of the former supposed valley, either as a wash in the colliery workings or as a surface feature, is wanted to support the river-bed theory, and it may perhaps some day be forthcoming.

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* Rev. W. Howchin in "Wilson's Handbook to Morpeth and Neighbourhood." Morpeth (1876), p. 109.

The other Northumbrian raised beach is one on the coast of Holy Island, just below the Beacon at its North-Eastern point. Here the section is as follows:—

	Ft.	In.
4 Clay without Boulders		
3 Brown Sand	0	4
2 Sands with Pebble Bands	3	0
1 Boulder Clay	10	0

Nos. 3 and 2 are the raised beach, and between 2 and 1 are to be seen in places indications of the old peat bed already referred to. *(See p. 14.)*

In Durham there is a better example of a typical raised beach. It occurs along the coast from Whitburn to Marsden, and can be traced almost completely round the hill on which Cleadon village stands. This Magnesian Limestone hill was evidently an island when this shingly beach was formed, and Boldon Flats were then an arm of the sea. A less well-marked raised beach can be traced at a higher level at some points, as, for instance, at Whitburn Lizards, where good sections, showing marine gravel, were exposed in a railway cutting some years ago.

Cave Deposits.—At this locality (Whitburn Lizards) some old sea-caves were discovered by Mr. John Daglish, F.G.S., in 1878, during the progress of his quarrying operations. In these caves—which are now, unfortunately, partly destroyed and partly covered up by quarry rubbish—remains of the Horse, Cow, Sheep, Dog, Pig or Wild Boar, Red Deer, Roe, Badger, Fox, Yellow-breasted Marten, Weasel, Hedgehog, Mole, Water Vole, Kestrel or Merlin, Gannet, the now extinct Great Auk *(Alca impennis)*, Razor Bill, and other birds were found, together with shells similar to those now common on the sea-shore (Limpet, Periwinkle, Oyster), and several human bones.*

Very similar remains—birds and sea shells excepted—were found in 1861 near Stanhope, in a cavern hollowed out of the Great Limestone (Carboniferous) at Heathery Burn. Besides the remains of man, there were bones of the Otter, Badger, Goat, Roebuck, Hog, Horse, and Water Rat.*

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* See R. Howse, "Preliminary Note on the Discovery of Old Sea-Caves and a Raised Sea-Beach at Whitburn Lizards."—*Nat. Hist. Trans. of Northumberland, Durham, and Newcastle-on-Tyne*, Vol. VII. (1880), p. 361.

Stone implements, made by the pre-historic inhabitants of Bernicia, have at various times been found, but they come rather within the domain of Archæology than of Geology. The Rev. W. Howchin, F.G.S., is among the luckiest of the local finders of such treasures.† It may be mentioned in passing that the heaps of stone picked off ploughed fields by the farmers, and so often met with by the roadside, are excellent hunting grounds for these antiquities.

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* See J. Elliot, *The Geologist*, Vol. V. (1862), pp. 34 and 167; Prof. T. H. Huxley, *id.*, p. 201; and Dr. C. Carter Blake, *id.*, p. 205.

† See "Notes on a Find of Pre-Historic Implements in Allendale, with Notices of similar Finds in the Surrounding District."—*Nat. Hist. Trans. of Northumberland, Durham, and Newcastle-on-Tyne*, Vol. VII. (1880), p. 210. See also Dr. J. Evans's classical work on British Stone Implements, where several local finds are recorded.

CHAPTER IV.

DRIFT DEPOSITS.

KAIMS, ESKERS, OR ÅSAR.—These, the newest of the glacial accumulations of Northern Europe, are still a puzzle to geologists. Their appearance is very distinct, and is nowhere better shown than in the lower ground bordering the coast in the Northern parts of the county of Northumberland. The North Eastern Railway between Alnwick and Berwick cuts through a number of unmistakable kaims, and others, equally good, are easily detected in the valley of the Tweed between Berwick and Carham. Indeed, the name "kaims,"—now generally adopted as a geological expression—is, in the district named, locally given to the Åsar. To take an example: The road from Lucker to Bamborough cuts through a true "kaim," part of a long series of them known as Bradford Kaims. To describe this one will be to describe all, as although in minute structure the constitution of these deposits varies *ad infinitum*, yet in general contour, aspects, and characteristics, they are remarkably similar. They are all ridges or elongated mounds of gravelly matter more or less irregular in shape, and all, from their universal position on comparatively low ground, and from other distinguishing features, give evidence of having been formed during a relatively recent submergence of the sea-board. They are thus to be looked upon as—in the last instance—marine deposits, but their stony contents are, from the striæ occasionally preserved on them and from their relation to the moraine heaps still left undisturbed on higher ground, of the same glacial origin as the latter.

The Bradford Kaims are a series of long, very irregular, meandering ridges of gravel formed of more or less rounded stones of all sizes from that of a walnut to a cubic foot or two.

They lie above the Boulder Clay, good sections of which can be seen in the limestone quarry close by, along the Glower-o'er-em (Glororum) road. Just as in the typical kaim districts of the valley of the Clyde, for instance, the Bradford Kaims occasionally enclose peat bogs, one of which is cut through by the railway to the South of Lucker. An opening by the roadside (a little to the East of Lucker Station) gives an excellent idea of the gravelly mass of which the ridges are composed and of their mode of arrangement.

In some cases, no doubt, there may be considerable difficulty in separating the Kaim gravels from the older Drift gravels on the one hand, and from the newer river deposits on the other, just in the same way as we have seen that these two classes of accumulations themselves sometimes defy separation. This difficulty, however, seldom exists with regard to the beautiful eskers of which we have spoken in the neighbourhood of Bamborough.

Good examples of kaims are to be seen at Chathill, Newham (part of the Bradford ridge), and Hoppen. "In these," says the late Mr. Tate, "I have recently (1866) found a few glaciated rocks among the waterworn gravel and sands of which these minor kaims are principally composed." *

Moor Gravels.—Under this name attention must be called to some little known and not very comprehensible deposits, concerning which the only definite statements that can be made are these:—They consist of well-rounded pebbles, generally—but not exclusively—derived from the neighbouring rocks. They are shapeless, the mounds which may be observed among them being usually due to the recent action of rain and streams. They are all at a considerable level above the sea. This, their last and most striking peculiarity, separates them from the eskers and from the other gravels already mentioned. The name *Moor Gravels* is suggested as implying no theory respecting their origin, and as indicating the fact that they occur on the high moorland portions of the country.

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* *Berwickshire Transactions* for 1866, p. 239.

They are very widely but irregularly distributed over Western and Central Northumberland, and can be well studied, for example (they are well worth study), on the moor tops between the Coquet and the Rede. That they are made up of glacial fragments is scarcely doubtful. They have much the appearance of water-worn moraine matter; but, from their position, the question "Whence comes the moraine matter?" is easier to ask than to answer. More facts are wanted before these and many other subjects connected with Drift are thoroughly understood.

Moraine Heaps.—Genuine moraine heaps do not abound in Northumberland or Durham; but still there are some, and a careful examination of the minor valleys in the West would probably add to the number known.

A very good example (the only thoroughly satisfactory one, indeed, that I am acquainted with) is to be seen at Whetstone House, near East Woodburn. Here a small crescent-shaped mound crosses the valley of the Lisle Burn, a tributary of the Redewater. The burn has cut its way through the centre of the mound, which is, therefore, not now entire. Its form can, however, be observed very satisfactorily, and as the southern arm of the crescent is quarried for stone, the material of which the barrier is composed can be perfectly well examined. These materials are sub-angular (*not* waterworn) fragments of the surrounding rocks, sandstone of the Carboniferous Limestone series predominating. In this crescent-shaped mound we have, there is every reason to believe, the actual terminal moraine of one of the last small glaciers of Northumberland. The Lisle Burn glacier was but an insignificant one when it left this little rubbish heap as the only token of its existence, but it was the remains of one of the chief branches feeding the great Redewater glacier, which itself united a few miles to the West with that of the North Tyne at Redesmouth. Indeed there is no difficulty in reconstructing with tolerable certainty the network of ancient glaciers which scored the Western part of the country towards the close of the last glacial epoch.

In the case of moraines, the conditions require that the fragments of rocks be to a considerable extent sub-angular—not rounded, as in true gravel heaps.

Upper Drift Sands and Gravels.—I have grouped under this name a set of gravelly deposits evidently more recent than the Boulder Clay—on which, indeed, they occasionally rest—which are often on too high ground to be looked upon as eskers or kaims, but too definite in shape and at too low a level to come under the head of *Moor Gravels.* That they are glacial there is no reason to doubt. If marine, it is clear that they are older than the Åsar of the coast—and they probably are marine, though we cannot prove them to be so. They consist chiefly of fine gravel, with occasional false-bedded courses of sand sometimes "scared" with coal, and they form conspicuous hummocky hillocks on ground averaging from 300 to 500 feet above the level of the sea. The castellated "dovecot" to the West of Bavington Hall stands on one of a number of these kaim-looking mounds. Another is well shown near Chollerton, on the Northern slope of the Drift-filled Erring Burn valley. Along the Southern and South-Eastern base of the Cheviot Hills, again, these sand and gravel "dodds"—as they are sometimes called—can be seen.

It may, perhaps, be urged that these gravels should be considered as the equivalents of the Drift sands and gravels which occur *in* the Boulder Clay, and it must be admitted that, were it not for the marked kaim-like forms which they often assume, there would be a good deal to say in favour of such a view, which, indeed, may after all turn out to be the true one.

For the present, perhaps, it will be safer to keep these deposits distinct.

Sometimes the drifted coal is present in such quantities as to form beds of considerable thickness and extent. The largest deposit of this sort known to me is one at Andrew's House, near Marley Hill, in North Durham, which was first observed by Mr. W. Scorer Harris in 1884.*

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* See Lebour "On Drift Coal in North Durham," *The Naturalist* for 1885.

Next come the great spreads of undoubted Upper Drift gravels and Sands, with occasional bands of unctuous clay, of which mention has been made before when speaking of the river gravels. These are very largely distributed in Northumberland and Durham, and fill most of the larger valleys. In that of the Aln they are strongly developed, and also in the Wansbeck, the Tyne, and the Derwent valleys. In the last-named some beautiful sections are to be seen, especially by the river-side, near Rowland's Gill, where the sands and gravel are well shown resting on the Boulder Clay. This is the case also near Mitford, above Morpeth, on the right bank of the Wansbeck. At Rothbury, likewise, they are seen in abundance, and, as Mr. Topley, F.G.S., has well remarked, the difference between them and the porphyritic river-gravel now carried down by the Coquet is extremely obvious. Above Wylam, opposite Corbridge, and at many other places in the neighbourhood the sands are predominant, whereas up the South Tyne the gravels are more frequent. In the latter valley, near Thorngrafton, striated pebbles (all of rocks foreign to the district) are plentiful, and would, no doubt, be found elsewhere if carefully sought for.

These sands and gravels still fill up a great number of valleys of which we only become cognizant by workings and borings for coal. Most of the "washes" which sometimes interfere so greatly with winning the coal—causing great gaps where solid rocks are expected—are of this kind. Thus the Rev. Mr. Howchin has been able to surmise, with great sagacity, that a former connection existed between the valleys of the Blyth and the Wansbeck. This case is not exactly analogous to that of the old Irthing valley discovered by Mr. Burns, and already referred to.

But it is perhaps in the valley of the Wear, about Durham, that this arenaceous Drift can be best studied. From some distance South of that city, to the Tyne at the mouth of the Team River, sands, gravels, and clays of Glacial age of great thickness are found, filling up a broad and deep valley. This great Wash, which once connected the Tyne and Wear, now actually forms the watershed between these rivers. It has been very fully described by Messrs. Nicholas Wood and E. F. Boyd in a classical paper read before the British Association at the Newcastle meeting in 1863.*

The Tees, again, did not always discharge itself at its present mouth. From Newport it, in pre-Glacial times, diverged into the county of Durham towards Saltholme, and ran along a valley bottom much beneath what is now low-water mark. This has been recently pointed out very clearly by Dr. W. Y. Veitch, of Middlesbrough.†

The Boulder Clay.—This has been often divided into Upper and Lower, and in some parts of England the division is undoubtedly a legitimate one, since there a great series of "middle sands and gravels" is seen to intervene. In Northumberland and Durham, however, the Boulder Clay is—with a few exceptions, which can be regarded *as* exceptions only—a homogeneous mass of stiff brown to bluish clay, laden with boulders of all sizes, limestone, sandstone, basalt, and porphyrite predominating, all rocks belonging to the surrounding district. Foreign rocks are usually present in the form of much smaller fragments. It may be stated that, as a rule, the upper portion of the Boulder Clay is freer from boulders than the lower, and that, as has been noted before, sands and gravels (of no great thickness or continuity, however) are sometimes found in the clay, occupying thus in a certain degree a position not unlike that of the middle sands and gravels. The thickness of the Boulder Clay is extremely variable, and its distribution is very wide. At the Boy's Reformatory, near Netherton, a boring for water was stopped in 186 feet of Boulder Clay—the greatest measured thickness I am acquainted with. The greater part of the coalfield may, speaking generally, be said to be covered with it, and its limit of height to the West is vertically great—reaches, in fact, 1,000 feet above sea level. That the Upper Drift Sands were deposited upon the denuded surface of the Boulder Clay seems abundantly proved.

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* See *Transactions of the N. of England Inst. Mining and Mechanical Engineers*, Vol. XIII.

† Proc. Yorks. Geol. and Polyt. Society, New Series, Vol. VIII. (1883), p. 221.

With one solitary exception, no fossils have been found in the clay. In this case, as was to be expected, the shells found belonged to Arctic species long extinct in British seas.*

Polished and grooved surfaces, due to glaciation of the older rocks, are frequent wherever the local conditions have favoured their preservation. On the Great Whin Sill, between Spindleston and Bamburgh, on limestone at Glororum in the same neighbourhood, at Belsay, and several places in Weardale, on sandstone at Hebburn, Plain Mellor, and Doddington, such markings have from time to time been beautifully shown, and at the last-named place there are good examples of *roches-moutonnées*.

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* In a paper "On the Glaciation of the Counties of Durham and Northumberland," by Mr. R. Howse, the following Schedule of the Superficial Deposits is adopted, viz.:—

"1. Beds of peat, and submarine forests with fossil remains of oak, alder, mountain-birch, and hazel; horns of *Cervus Alces* and *Cervus Elaphus*, *Bos primigenius*, etc.
"2. Rubble transported from moraine heaps of upper valleys.
"3. Gravel beds, forming remains of ancient raised beaches.
"4. Sand, forming elevated mounds along the courses of valleys.
"5. Brick-clay, with intercalations of laminated clay, sand, and peat-bed containing skeleton of *Megaceros Hibernicus*, and stems of *Calluna vulgaris*.
"6. ? Scandinavian drift, containing angular flints, and small fragments of rock, probably derived from boulder-clay.
"7. Boulder-clay or drifted glacier-moraine containing fragments of *Cyprina Islandica*.
"8. Ancient gravel bed resting on rock surface":
—Transactions of the *North of England Institute of Mining Engineers*, Vol. XIII., (1863-4), p. 170.

CHAPTER V.

THE TRIAS AND PERMIAN.

The Salt-Measures or Permo-Triassic Red Beds:—The dreary red-soiled flat which extends from Seaton Carew to the Tees and over much of South East Durham, has in recent years had a flood of light poured upon its geology by the many borings for salt which have been put down within the area they occupy. It is a Drift-covered country, and the Drift is strongly stained by the iron-reddened rocks over which it is spread. These rocks consist of a thick series of alternating sandstones and arenaceous marls of various tints of red with occasional patches of a whitish hue. The uppermost beds of this formation do not crop out North of the Tees, but at Eston on the Yorkshire side, they have been found at a small depth from the surface capped by fossiliferous layers of Rhætic age. The red sandstones themselves have not yet yielded fossils of any kind, but they appear to lie perfectly conformably beneath the *Avicula contorta* series, and, so far as their higher portions are concerned, are undoubtedly of Upper Triassic or Keuper age. As the borings deepen the red sandstones contain interbedded bands of Gypsum and Anhydrite with, still lower down, occasional thin irregular strata of dolomitic limestone. It is in this part of the series, but not at any strictly defined horizon within it, that valuable beds of rock salt 100 feet and more in thickness have been found. The thin bands of limestone are fœtid, and, when fresh, emit a strong smell, similar to that of petroleum, on being struck with a hammer. This portion of the Salt-Measures appears to be of Upper Permian age, and is the exact counterpart of the rocks of that age which in Germany are known as the Rauchwacke. The characters of that division are: stinking bituminous dolomitic limestone in very variable layers, and red marly sandstones with intercalated masses ot Gypsum, Anhydrite, and Rock-salt, just as in South East Durham. In some cases the limestone bands have proved unusually thick, as at Haverton Hill, but in no case is there, in my opinion, any reason for supposing that the main mass of the great Permian Magnesian limestone has been reached by any of the salt borings yet put down.

All the sandy portions of these Salt-Measures are much false-bedded, and all the other members of the series are prone to continual thinning and thickening, so that a strict correlation of the divisions proved by the different borings is exceedingly difficult. This difficulty is much increased when it is remembered that there is the possibility of two planes of unconformity being present—one between the upper and the lower Trias, and the other between the Trias and the Permian. But such unconformities, if they be present, cannot be proved by the narrow cores which is all that borings give us to examine. The classification of the rocks between the Permian Magnesian Limestone, and the Drift is, therefore, in Durham, a very doubtful matter, and I give the following scheme merely as representing my own opinion as derived from a careful examination of the evidence at present available on the subject:—

	Avicula contorta Beds (proved in Eston shaft and boring...	Rhætic.
7.	Red and Green Marls, with Gypsum (known only South of Tees)	Upper Trias.
6.	Red Sandstone	
	Unconformity ? ?	
5.	Red Sandstones and Marls	Lower Trias.
	Unconformity ? ?	
4.	Red Marly Sandstones, Marls, with lenticular beds of Anhydrite, Gypsum, and Salt, and fœtid limestone in variable bands towards the base	Upper Permian (Rauchwacke).
3.	Thick Magnesian Limestone	Middle Permian.
2.	Marl Slate, with Fish Bed	
1.	Yellow Sands	Lower Permian.
	Unconformity.	

Perhaps a better idea of the state of things may be gathered from a summarised account of an actual boring. Thus, at bore-hole No. 1, at the Clarence Salt Works, on the Durham side of the Tees, the section was found to be as follows;—

	Feet.
Peat and soil *(Recent)*	8
Blue Clay *(Sub-Recent)*	32
Brown and Red Boulder Clay *(Glacial Drift)* ...	56
Red Sandstone *(Upper and Lower ? Trias)*	391
Red Sandstone and Marl *Do.*	303
Marl and Gypsum *(Upper Rauchwacke Permian)*...	253
Rock Salt *Do.* ...	65
Rock Salt and Gypsum *Do.* ...	12
Total depth,	1,120 ft.

In an adjoining and deeper bore-hole the lower portion of the series was better shown, the thin variable limestones of the Rauchwacke having been reached. After passing through Red Sandstones and Marls, as in the last section, to a depth of 1,098 feet, the following beds were met with, all probably to be referred to the Upper Permian:—

	Feet.	Inches.
Strata	1,098	0
Gypsum and Anhydrite	11	3
Marly Sand and Sandstone, with Salt... ...	27	4
Rock Salt	64	5
Rock Salt, with Marl and Gypsum	35	0
Soft Shale and Gypsum	8	0
Gypsum	13	0
Gypsum and Limestone	12	0
Limestone, with Gas at the rate of 39 cubic inches per minute	45	0
Grey Limestone, mixed with Gypsum below	20	0
Gypsum, mixed with Salt below	3	0
Rock Salt	14	0
Marl, containing Salt and Gypsum	3	0
Impure Rock Salt	1	0
Total depth,	1,355	0*

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* See T. H. Bell, "The Salt Deposits of Middlesbrough, and the mode of working them," *Proc. Cleveland Inst. of Engineers* for 1882-83, p. 106.

When I first entered upon the study of this question I was strongly prejudiced in favour of the view of the stratigraphical relations of these beds which is represented by the scheme according to which the Maps of the Geological Survey are coloured, viz.:—

Rhætic.
Upper Trias (Keuper): { Red and Green Marl with Gypsum (*f.* 6).
Red and White Sandstone with beds of Red Marl, Gypsum, and Rock Salt (*f.* 5).
Permian: Magnesian Limestone.

But there seems to be no good reason, in the total absence of fossils, for separating what I have called No. 4, into two divisions, the lower with, and the upper without, limestones. It is true that the reason for separating No. 5 from No. 4 is scarcely stronger, except that there is a distinct evidence that the former division now occupies a larger area than the latter, which is proof of overlap, if not of unconformity. There is also some, though less, evidence of No. 6 overlapping No. 5, or being unconformable to it, and there seems to be absolutely nothing in favour of the assumption that (whichever classification be adopted), the Triassic series is in South Durham only represented by the Keuper. On these grounds, therefore, and on others which it would be out of place to discuss at length here, I have gradually been brought to adopt the arrangement above given as that most consistent with known facts.

The exact outcrop of the Red Beds of South Durham cannot be traced, owing to the Drift by which it is concealed, but on the Survey Map it is drawn approximately as running from the coast between West Hartlepool and Seaton Carew (where the Long and Little Scar rocks are of red sandstone), due South-West a little to the North of Wynyard by Grindon, Stillington to Barmpton and Haughton-le-Skerne, thence a little to the East of Darlington to just West of Croft, where red sandstones are again seen as the outcrop crosses the Tees, dipping 10° a little to the West of North. At Haverton Hill boring, still higher up, dips were proved (as high as 30°), but, generally speaking, these beds are nearly flat.

The beds of limestone associated with the Salt and Gypsum are nowhere seen cropping out at the surface. That which at West Hartlepool and Croft emerges from beneath the Red Rocks is the great Middle Permian Magnesian Limestone, which attains its most remarkable development in the County of Durham.

Magnesian Limestone.—This well-known rock occupies the coast-line of Durham from West Hartlepool to South Shields, and probably no other British rock offers so many types of structure displayed in a finer continuous section. Its name sufficiently denotes its common dolomitic character, but it is frequently a misnomer, and the amount of Magnesian Carbonate present in the stone varies from 0 to 40 per cent.* In structure it is equally variable. The late Professor Sedgwick, whose early papers on this formation are as valuable at the present day as when they were written sixty years ago, describes the following lithological varieties as occuring within the County in what he calls the "Great Middle deposit of Yellow Magnesian Limestone":—

1.—*Small-grained Crystalline Dolomite*, found at Coniscliff, Castle Eden Dene, Tunstall Hill, the Black Rocks, and elsewhere on the coast.

2.—*Compact Magnesian Limestone.* This is rare in Durham, but sometimes occurs locally.

3.—*Limestone with laminated structure*, abundant in quarries near Sunderland, on the coast, as at Marsden, where thin flexible laminæ can easily be obtained of a considerable size. After being kept some time in a dry locality, however, the flexibility of this stone disappears.

4.—*Earthy Magnesian Limestone*, very abundant and most erratically distributed in irregular masses of all shapes among the more stony rock. It is the "marl" of the Magnesian Limestone quarrymen, and much of the cavernous nature of the formation is due to the readiness with which this earthy matter is washed away from the cavities which it occupies. It is often richer in magnesia than the harder forms.

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* See Browell and Kirkby's "Analyses of Magnesian Limestone" in the *Transactions of the Tyneside Naturalists' Field Club.*

5.—*Limestone with large irregular concretionary structure.* "Under this subdivision are included all those parts of the deposit which are composed of great irregular concretions, and in which the subordinate parts exhibit a complex irregular structure. These modifications may often be traced in the separate beds of an escarpment which is distinctly stratified. They are, however, seen in the most impressive form when, to all appearance, an entire system of beds has been so changed that the lines of deposit are obliterated, and the whole escarpment shows an amorphous mass of crystalline, compact, cellular, and earthy materials rudely blended together, and apparently passing into each other without order or arrangement."*

6.—*Rocks of a brecciated structure.* These are of two kinds. First, great beds, which appear to have been broken up into innumerable angular fragments, and to have been recemented in a matrix similar to themselves in composition. Secondly, what I have termed "Breccia Gashes," that is to say, fissures or caverns in the rock which have been filled up by a loose breccia due to the falling in of their walls and roofs, the fragments being, as before, firmly held by more magnesian limestone deposited by the agency of water.† The first, or bedded breccias are well seen at the Tynemouth Priory cliff, and at many points on the coast of Durham. To me they are as yet unaccountable. The Breccia-gashes which I have endeavoured to explain without calling in the aid of true earthquakes are beautifully shown in the cliffs between Frenchman's Bay and Marsden Rock.

7.—*Small concretionary structure,* which may include the many cases in which the rock assumes from an oolitic to a coarsely pisolitic structure. The finer forms are seen in the cliff on the East side of the promontory of Hartlepool, the coarser at Roker.

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* Sedgwick "On the Geological Relations and internal structure of the Magnesian Limestone, etc.," *Trans. Geol. Soc.* London, Ser. 2, Vol. III. (1835), read 1826-1828, p. 87.

† Lebour "On the Breccia-Gashes of the Durham Coast and some recent earth-shakes at Sunderland," *Trans. North of England Inst. Mining and Mechanical Engineers,* Vol. XXXIII. (1884); also *Geological Magazine,* (1885).

8.—*Limestone with large globular concretionary structure.* This is the well-known Cannon-Ball Limestone of Fulwell and the Coast between Whitburn and Marsden. A more extraordinary rock-structure or one more peculiar to a special district is not known to me.

All the above-mentioned appearances of the Permian Magnesian Limestone of Durham are local, and none appears to me to be absolutely restricted to or characteristic of any particular horizon in the formation along its entire course—even within the narrow limits of the county. Certain structures are, it must be admitted, found oftener at certain horizons than at others, but, so far as my observation goes, they do not enable one to trace each horizon for any great distances. Mr. R. Howse, however, whose knowledge of the formation is probably more complete than that of any other living geologist, has felt justified in dividing the series ix lithological sub-groups. These are—

1. Upper Group ...	... *a.* Upper-yellow-limestone *b.* Botryoidal limestone.
2. Middle Group ...	... *c.* Cellular, and *d.* Shell-limestone.
3. Lower Group ...	... *e.* Compact limestone, and *f.* Conglomerate.[*]

Treating the Magnesian Limestone as a whole, its outcrop forms one of the chief features in East Durham—a fine, though not very elevated, escarpment facing Westward and indented into a great number of narrow bays by denudation. The following places, from North to South, are on the inland promontories of this escarpment, and serve to indicate clearly the range of this singular rock: Westoe, West Boldon, the Durham Monument, Newbottle, Pittington Hill, Sherburn Hill, Strawberry Hill, Old Cassop, Quarrington Hill, Coxhoe House, Merrington and Middlestone, Tottenham and Grange Hill, Eldon, Midderidge and West Thickley, Thickley, Redworth White House, Killerby and Headlam, the White Cross, whence, at Pierce Bridge, the formation crosses the Tees into Yorkshire. In Northumberland the Permian system is represented by four small patches only, namely, at Tynemouth, Cullercoats and Whitley, Hartley, and Closing Hill near Killingworth. Of these, only the first two comprise any portion of the Magnesian Limestone. At Tynemouth cliff the Middle Limestone is the highest member present, and is very much denuded. It is difficult of access, but a number of fossils are recorded from this locality. The rock here is thus described by Mr. Howse, as the *cellular limestone:*—"An amorphous irregular deposit of highly crystalline or saccharine limestone, occasionally full of small, irregular cavities, partially or entirely filled with a fine earthy powdery substance; other parts present the appearance of being formed of shapeless fragments of compact limestone imbedded in a complete investing matrix, without taking the form of a true breccia."*

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[*] R. Howse "Notes on the Permian System of Northumberland and Durham," *Trans. Tyneside Nat. Field Club*, 1858, p. 4. See also Kirkby and Binney's "Tabular View of the Permian Strata of the North-East of England," *The Geologist*, Vol. VI. (1863), p. 364; and Daglish and Forster "On the Magnesian Limestone of Durham," *Trans. North of England Inst. Mining and Mechanical Engineers*, Vol. XIII. (1864), p. 20.

Below this lies the Lower Division, well known at Tynemouth and Whitley quarries, to the West of Cullercoats, where the Permians have been thrown down to the North by the great fault known as the "Ninety Fathom Dyke." This rock is a compact limestone, passing locally into a conglomerate. At the quarries, now used as a reservoir by the North Shields Water Company, the limestone can be well studied, but neither its top nor its base is now visible.

The Marl Slate.—This name is given to a thin bed, composed of many laminæ of flaggy arenaceous limestone. It is generally greyish, passing to yellow, and is remarkable for the number and beauty of the fossil fishes and other vertebrates it contains. At Tynemouth and Cullercoats it is situated near, but not quite at, the base of the main mass of the Magnesian Limestone, but elsewhere it very generally occurs immediately below it and above the Yellow Sands. Were it not for the interesting group of organic remains found in the Marl Slate, it would, no doubt, be properly regarded as merely a subordinate member of the limestone, although occasionally there are distinct signs of unconformity between the two. This is notably the case at Claxheugh where a splendid section is exposed on the South bank of the Wear about two miles above Sunderland. Clear as the fact is that here, at all events, the Marl Slate was disturbed and denuded before the deposition of the Magnesian Limestone over it, the unconformity is probably only a local one with no general significance, and is no greater than may be observed in many places between the higher subdivisions of the Limestone.

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* *Op. jam. cit.*, p. 4.

Occurring, as it does, at the foot of the escarpment of the Magnesian Limestone, the Marl Slate is generally covered up by talus-débris from above, and only visible at a few spots. Cullercoats at the lowest tides, Tynemouth Cliff, Claxheugh, the railway cutting at Ferryhill, and Midderidge Quarry—where some of the finest and most unique fossils of the formation were discovered by the late Mr. Joseph Duff, of Bishop Auckland—offer the best exposures of this rock.

The Yellow Sands.—This is a very irregular, though important deposit. It was the earliest accumulation in the district during Permian times, and is found filling up the hollows of the denuded surface of the Carboniferous rocks beneath—thick where such hollows are deep, thin where they are shallow, and non-existent where they give place to protuberances. The name "Yellow Sands" accurately designates the ordinary nature of the rock, in which the grains of sand are seldom so firmly cemented together as to form a sandstone or grit. As a rule it is friable and incoherent. Sometimes, as at Cullercoats, where the Smugglers' cave is excavated out of this division, the rock is calcareous in spots. This gives rise to a curious knobby appearance of the weathered surfaces, where each knob represents the segregation of calcareous cementing matter round a point. The grains of quartz of which the sands consist are generally coarse and well-rounded, but there is considerable variation in their size from place to place.

This lowest Permian is all that can be seen of the system at Hartley, where it caps the cliff near the old lime kiln, and at Closing Hill Quarry, near Killingworth. It is, however, best seen at Cullercoats and Tynemouth, in Northumberland. South of the Tyne it is often covered by Drift or talus débris at its outcrop, and in some cases it is overlapped by the overlying limestone. It may, however, be easily traced from Westoe, by Harton village, to Cleadon Laws, from West Boldon to Southwick. On the South bank of the Wear it is splendidly shown at Claxheugh, and thence nearly all the way along the foot of the Permian escarpment to Houghton-le-Spring. It crops out again at High Downs, near Rainton, from Hetton-le-Hole to Pittington, from Littletown, round Sherburn Hill, to Ludworth, from near Old Cassop, skirting Quarrington Hill to Coxhoe Colliery. Lastly, it is excellently exposed in the railway cutting at Ferryhill, where, indeed, the three lower divisions of the Permian are capitally shown, and close by round a small outlier of Magnesian Limestone at Well House Brewery.

The numerous collieries which are situated on the Magnesian Limestone of Durham furnish us by means of their shafts and borings to the Coal-Measures with much information respecting the Yellow Sands between its outcrop and the sea. Both the Magnesian Limestone, on account of its many cavities, and the Yellow Sands, because of their open and incoherent texture, are water-bearing horizons, and many a fight has taken place between engineering skill and capital on the one hand, and the mighty rush of water from these beds on the other in winning the coal below. Much of practical interest, therefore, depends upon the distribution and thickness of these Sands. At Murton Colliery, the Yellow Sands were found to be about 30 feet thick, and yielded an enormous amount of water. At Thornley, they were 36 feet thick; at Shotton, 24 feet; at Seaham and Seaton Collieries, only 3 feet; at Ryhope, they attained a thickness of 96 feet 3 inches, whereas at Monkwearmouth and several other places they were wanting altogether.*

The Yellow Sands are everywhere unconformable upon the beds beneath them, and therefore, though no fossils have ever been found in them, there can be no hesitation in classing them with the Permian, and not with the Coal Measures.

The figures on Plate III. illustrate some of the chief points referred to in this Chapter.

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* See *Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. XIII., p. 106.

CHAPTER VI.

THE COAL-MEASURES.

SINCE the Permian rocks are unconformable upon the Carboniferous, it will be evident that we could scarcely expect to find the uppermost beds of the Coal-Measures in Northumberland or Durham. As a matter of fact, these beds are not present, and, although we have some two thousand feet of rock belonging to this division, we are unable to say how much more was denuded away before the deposition of the Yellow Sands. The denuded edges of the Coal-Measure sandstones and shales have, however, for a certain depth below their junction with the Lower Permian, a character in common which has led to their often being classed with the Permian, and I was myself for some time misled into taking this view by noting how constantly in accounts of borings and sinkings red beds were recorded as immediately underlying the Yellow Sands. Sir Roderick I. Murchison and others looked upon these red rocks as corresponding to the "Roth-todt-liegende," or Lowest Permian of the Continent, though Messrs. Daglish, Forster, Atkinson, and others have always stated their conviction that they were merely the ordinary Coal-Measure rocks stained red at and near their line of contact with the overlying Permian. This conviction increased experience and observation cause me now to share completely. I would add that the red colour of these rocks has been in all probability obtained at the expense of the Yellow Sands, which were very likely once red too.

In other Coal-fields the Coal-Measures are often divided into Upper, Middle, and Lower. This has been attempted in this district; but, owing to the facts just stated, there are many objections to this mode of procedure. I have, therefore, adopted a plan which I elsewhere proposed*—namely, that all the beds from the highest-*known* in the Coal-Measures in the district down to the Brockwell Coal inclusive (that is to say, all that series which contains the best coal seams) should be called Coal-Measures simply, without further subdivision, and that the beds below the Brockwell, and as far down as the top of the first important and recognisable band of limestone of the Carboniferous Limestone series, should be grouped together as the "Gannister and Millstone Grit Series." This is the arrangement followed here.

Speaking lithologically, and in the order of prevalence, the Coal-Measures of the Newcastle Coal-field consist of alternating beds of Sandstone, Shale, Fire-Clay, and Coal, the chief characteristics of which may now be given.†

Shales.—The shales of the Coal-Measures are not distinguishable lithologically from those of the other divisions of the Carboniferous rocks of the two counties, save that they are but rarely calcareous (seldom yielding more than 2 per cent. of lime, according to published analyses, and usually far less), and are more frequently bituminous. The number of varieties is very great, and a series can easily be arranged showing a perfect gradation from splint coal on the one hand, through bituminous shale (or black shale), non-bituminous shale (blue shale), grey shale, micaceous shale, and arenaceous shale, to true sandstone on the other. Locally, shale is called *Plate* or *Metal*, and the convenient term *Grey Beds* is used to denote the many-bedded alternations of sandy shales and shaly sandstones, generally micaceous, which form much of the main bulk of the Upper Carboniferous series.

Many of these shales contain nodules and continuous bands of clay-ironstone, some of which have been worked from time to time, but cannot now be said to be remunerative under ordinary circumstances. Some of the continuous ironstones will be referred to presently under the heading of "Mussel Bands."

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* *Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. XXV., 1876.

† The North of England Institute of Mining and Mechanical Engineers have now issued (1886) the first three volumes of an almost complete collection of all the measured sections and borings in Northumberland and Durham. The collection, when the whole is published, will render it possible to sectionise the Coal-field in a manner quite unequalled in any other part of the world.

It is common for the larger coal seams to be covered by black shale, and some theories concerning the origin of coal have been based on a hasty assumption that this was always the case. It is not so, and many cases can be adduced where in this coal-field, the coal is succeeded by grit, and, in the Lower Carboniferous, by limestone. When, however, shales cap the seams, they are often very rich in vegetable remains, and it is this that calls our attention more particularly to these ancient compressed mud-beds. Ferns, Calamites (ancient *Equisetæ*, or Horse Tails), Lepidodendra (allied to our Club Mosses), and Conifers, abound, with other less well-defined forms, in many of these shales, more especially in the less micaceous or sandy varieties. Naturally enough, the fossil contents of those beds are best known which are associated with the most commonly worked coal-seams. Thus, the plants of the High-Main, the Bensham, and the Low-Main Shales have long been collected and described, whereas, unfortunately, other horizons, very likely quite as rich and interesting, are still undiscovered or but little known.

But, besides plants, some of these shales have proved extremely prolific in the remains of fishes and amphibians.

It is mainly owing to the unwearied industry of one man, the late Mr. Thomas Atthey, A.L.S., of Gosforth, that we are enabled to view side by side, and in a remarkably complete manner, the fauna and flora of one great horizon in our Coal-Measures. The animal and vegetable life which thronged East Northumberland shortly after the deposition of what we now call the Low Main Coal is better known to us than that of many parts of the living world. A portion of the shale overlying this seam is a true fish-bed, the minute searching of which was a labour of love to Mr. Atthey for many years, and from which an unequalled collection of fish and amphibian remains has been obtained.*

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* This collection has been acquired by the Natural History Society of Northumberland and Durham, in whose beautiful new museum it now lies.

These animals, as will be seen by the lists at the end of the volume, all belong to species which lived, probably, in fresh or merely brackish water, no evidence of purely marine conditions being, therefore, forthcoming from this source. The ocality whence most of these specimens come is Newsham, near Blyth, but the fish-bed appears to be very constant, and has been recognised in various other parts of Northumberland, and in Durham.

Mussel Bands.—Geologically, perhaps the most interesting beds in the Coal-Measures of this district are the thin deposits known as *Mussel Bands.* These are layers seldom more than a few inches in thickness, consisting almost entirely of the shells of *Anthracosia*—a genus of molluscs allied to the mussels of our rivers, and supposed (although not on perfectly conclusive evidence) to be of fresh water, or at least brackish, habit. Along with them shells, bits of drifted wood belonging to common Carboniferous forms, and impressions of ferns, are occasionally found. These little shell-beds contain usually a considerable percentage of iron, in certain cases sufficient to allow of their being worked as ironstone. The following analysis of one of the best-known and most persistent of these bands is given by Messrs. Clapham and Daglish * :—

	Soluble in Acid.	Insoluble in Acid.
Silica	trace	31·068
Alumina	1·194	16·292
Lime	4·084	0·988
Magnesia	1·078	0·288
Potash	1·319	—
Sulphate of Soda	trace	—
Protoxide of Iron	18·637	—
Water of combination	11·221	—
Carbonic Acid	14·057	—
	51·590	48·636

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* *Transactions of the North of England Institute of Mining Engineers*, Vol. XIII. (1863-64), p. 221.

The horizon of this mussel-bed is a few feet above the Low-Main Seam; another equally constant zone of this kind occurs in connection with and above the High-Main Coal. Altogether, not less than seven *Anthracosia* bands are known in the Coal-field, and of these the exact position of two is doubtful. At Whitley, at the base of the cliff, the shell-bed can be very well seen in places at low water, and the old shale-heaps above abound in excellent well-weathered specimens. In the cliff near Hartley there is also a good exposure of the kind.

These Coal-Measure Mussels do not only occur in closely-packed colonies, such as those above referred to. Mr. G. Hurst has found them in isolated specimens, here and there, in the shale next above the Yard Seam at Seaton Delaval Colliery; and so has Mr. J. Southern in the roofs of the Beaumont and Five-Quarter Seams at Heworth Colliery.*

One of the highest shell-beds of the Coal-field has, in Durham, at Ryhope, yielded a marine shell (or, at all events, one belonging to a genus which, although known to be sometimes estuarine, has no claim to be regarded as fresh-water) —viz., a *Lingula*. No example of the kind has yet been recorded from Northumberland from any horizon above the Gannister Beds (Lower Coal-Measures of authors).

Sandstones.—The Grits and Sandstones of the Coal-Measures are, as a rule, fine-grained, and of a greyish or yellowish colour; but, in truth, they can scarcely be said to have any special character which they do not share with the arenaceous beds of the older members of the Carboniferous series. There is always iron present in appreciable quantities, the per centage of oxide of iron being sometimes as high as 10, and seldom lower than 1, the average being about 5. It may be noted that the dark colour of the rock is by no means a sure test to apply in estimating the amount of iron present, the *grey* sandstones usually containing more than the *brown*; the white beds being, however, very poor in that substance.

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* Notes to this effect were read at the first ordinary meeting of the Durham College Geological Club on the 19th March, 1886. See *The Durham University Journal*, Vol. VII., p. 29.

The richest are, generally speaking, the micaceous varieties. Messrs. Clapham and Daglish* remark that "the chief characteristics of the sandstones seem to be the quantity of iron, lime [very rarely exceeding, or even reaching, 2 per cent., however], or magnesia they contain, which is the cause of their decomposition when exposed to the action of disintegrating agents."

There is in most of these beds a tendency to segregation of colouring matter in the form of concentric bands of various tints, sometimes giving rise, after long exposure to the air, to singular variegated effects. This is well shown in many of the dressed-stone buildings of Newcastle and Gateshead. The concretionary action is often accompanied by exfoliation and disintegration.

The thick sandstone known locally as the Grindstone Sill or Post, whence the celebrated Newcastle grindstones are cut, exemplifies the above remarks. It is on the whole a fine-grained, moderately hard, light-yellow stone; but it is in places porous enough for the manufacture of filter stones, which were formerly extensively made from it,† and its upper part is often "abundantly impregnated with yellow ochre, which is sold under the name of *die-sand*." The chief heights of Newcastle are formed of this bed, as at Byker, Benwell Hill (Condercum), Kenton, etc. The Burradon fire-stone, near Killingworth, belongs to the same deposit.‡

It will be seen that variation is common with these sandstones, and this is the case not only in composition, but also, and still more markedly, in thickness. In the excellent coast-sections between Seaton Sluice and St. Mary's Island instances of very rapid thinning and thickening on the part of both sandstones and shales are frequent, and again in the rocky cliffs between Whitley and Cullercoats. How variously these changes affect the dips of the beds locally seems very obvious, but, strange to say, this appears to be by no means universally understood.*

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* *Loc. cit.*, p. 221.

† N. J. Winch, *Transactions of the Geological Society*, Vol. IV., p. 17, 1816.

‡ The sandstones enumerated here all belong to one series overlying the High Main Coal, and subdivided locally as follows, in ascending order:—1. Main or High Main Post. 2. 70-fathom Post, in one, two, or three members parted by very variable shales. 3. The Grindstone Post. *Post* is the local term for sandstone, but is applied also to any distinct massive bed, thus a "post of limestone" is often spoken of.

There does not appear to be any noticeable change in the general character of the sandstone beds from the highest to the Brockwell seam, unless it be perhaps that in the lower ones nests of well-formed quartz-crystals are commoner, as is the case in the district between Wylam and the Derwent.

In all, or nearly all, the remains of plants are common, Sigillarian stems predominating, but Lepidodendra, and Calamites often occurring also as casts more or less coated with carbonaceous matter. Many of the finest fossils of this description have been found in one or other of the numerous quarries in the outskirts of Newcastle, some indeed having acquired a more than local celebrity, such as the once well-known Wide-Open tree, from Wide Open Quarry, between Seaton Burn and Gosforth.

Fire-Clays.—Generally forming the floor of Coal-seams, but occasionally unconnected with them, we find throughout the Coal-Measures a number of deposits of more or less siliceous clay known as Under-clay, Seggar-clay, or Thill, and often used as fire-clay. These deposits are common to all Coal-producing districts. They are the impermeable clay-bottoms which allowed the swamp-vegetation of the Coal to flourish, and we may with propriety liken them to the clayey marls which we find supporting the growing peat of our bogs.

These Seggar-clays are, as a rule, full of the large roots of Sigillarian plants known as *Stigmariæ*, and more especially of the long leaf-like rootlets springing from them. The association of the Coal and its under-clay, and that of Sigillaria with Stigmaria, are themes always dwelt on at length in elementary text-books of Geology. They are now well understood, and need not, therefore, detain us here.

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* See W. Topley, F.G.S., "On the Correspondence between some Areas of apparent Upheaval and the Thickening of Subjacent Beds," *Quarterly Journal of the Geological Society*, Vol. XXX. (1874), p. 186.

Almost every Seggar is more or less of a fire-clay, the best adapted for refractory purposes containing a large amount of silica, and being comparatively free from lime, iron, and other impurities.

The following analysis of a local under-clay is given amongst others by Mr. Joseph Cowen, and is quoted here on account of the unusually large percentage of silica:—

Silica	83·29
Alumina	8·10
Iron and Lime...	2·43
Magnesia	2·99
Water and organic matter	3·64
	100·45*

Coals.—Owing to the varying thickness of the sandstones and shales intervening between the Coal seams, to the inconsistent and ever-varying nomenclature of the latter, to the numerous intersecting faults, and—more than all the rest—to the thick covering of Drift which obscures the greater portion of its area, it was long before the structure of the Coal-field was well understood. In 1814, Mr. Winch thus spoke on the subject:—

"It is not possible to discover in the Coal-Measures any regular order of succession which will apply to the whole Coal-field, and it is even with difficulty that in very limited portions of it the continuity of particular seams can be traced. This arises from the variable thickness and the rapid enlargement and contraction of the different beds; that which in one section is scarcely perceptible, having attained in a neighbouring pit the thickness of several fathoms. . . . . It is useless, therefore, to attempt any general section of the Coal formation."†

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* "Industrial Resources of the Tyne, Wear, and Tees." Ed. 2 (1864), p. 207.

† *Transactions of the Geological Society*, Vol. IV., pp. 12-13 (1816).

The late Mr. Buddle was the first to bring order into the apparent chaos thus described. In his luminous "Synopsis of the Seams of Coal in the Newcastle District," read, in 1830, before the Natural History Society of Northumberland, he laid the foundation of all that has since been done in unravelling the geological features of the district. In a masterly manner he seized the main features of the lie of the beds, and described them so thoroughly and clearly that since his time it is only in matters of detail that his synopsis has been found wanting.*

Taking the best known coals only, and following in the main the views of Mr. J. B. Simpson, F.G.S.,† as the latest and most exact exponent of the series first tabulated by Buddle, we have the following seams in the Coal-Measures from the highest known in the Coal-field to the Brockwell:—

COAL SEAMS.

21. *Closing Hill Seam.*—Described by the late W. Hutton, on the authority of the late Mr. N. Wood, as cropping out on the North—or downthrow—side of the Ninety-Fathom Dyke, in a quarry about 800 yards South of Killingworth House. The seam was 20 inches thick, and is worth noting, since it is quite the highest recorded in the district, being, according to Mr. Hutton, at least 450 feet above the next-mentioned coal, which is usually looked upon as the highest.

From its position, the area of this seam is necessarily limited in extent to the immediate neighbourhood of the spot noted. Very little is known of this coal, which may possibly be the same as the highest met with in the Boldon Colliery pit on the South or Durham side of the Tyne, near Brockley Whins.

Strata—About 450 feet.

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* *Transactions of the Northumberland Natural History Society,* Vol. I., pp. 215-240 (1831).

† See the Sheet of Sections published by Mr. J. B. Simpson, and entitled "The Coal Seams of the Northumberland and Durham Coalfield" (1877).

20. *Hebburn Fell*, or *Monkton Seam.*—About 2 feet 8 inches thick. It extends over a very limited tract of country in the Hebburn and Jarrow district, and is of inferior quality.

Strata—About 250 feet.

19. *Five-Quarter Seam.*—About 4 feet thick. Probably the highest seam in the Cowpen district. (Not to be mistaken for the lower Five-Quarter seams.)

Strata—About 260 feet.

18. *Three-Quarter*, or *Blackclose*, or *Moorland*, or *70-Fathom Coal.*—In the Cowpen and Gosforth district about 2 feet thick, often less. The Blackclose, or Moorland Seam, is by some held to be the High Main.

Strata—Very variable, 50 to 180 feet.

17. *High Main*, or *Main*, or *Seven-Quarter*, or *Glebe Coal*, or *Shield Row* of Pontop, or *Three-Quarter* of the Hetton district. —About 6 feet thick. This seam is often taken as the boundary between the Middle and Upper Coal-Measures: a view that I cannot agree with. That it is in a sense a natural limit of some kind cannot be denied, since it separates a series of thick and tolerably constant sandstones above it (including the Grindstone and Seventy-Fathom Posts) from the rest of the Coal-Measures. Formerly it was the most valuable seam in the Coal-field, but is now almost entirely worked or burned out. Between the Tyne and the Ninety-Fathom Dyke the coal was at its best; but it also underlies a considerable extent of country to the North, between Denton and the mouth of the Wansbeck. It is the type "Wallsend" household coal.

Strata—Very variable, seldom more than 150 feet.

16. *Metal Coal.*
Strata—33 feet.
15. *Stone Coal,*

or *Grey Seam.*
or *Blake Seam*
of Seghill.

These two seams are separate on the Tyne, and continue so for some distance to the North and East, but to the North and West they coalesce and form what is known as the Grey Seam, a coal which attains a thickness of nearly 8 feet at Cramlington. The Metal and Stone Coal are said to unite again in Durham, where, together, they form the "Five-Quarter Seam" of the Coxhoe and Thornley district.

Strata—Variable, 60 to 110 feet thick.

14. *Yard Coal*, or *Main Coal* of the Wear.—About 2 feet 10 inches to 4 feet thick. Above this seam is a shale in which fish remains are found.

Strata—60 to 100 feet thick.

13. *Bensham Seam.*—2 feet 5 inches to 5 feet thick. This is the Maudlin Seam of Durham. At the Felling the Bensham and Six-Quarter Seams together form the Maudlin Seam.

Strata—About 75 feet, with thick sandstone at base.

12. *Six-Quarter Seam*,
Strata—25 feet.
11. *Five-Quarter Seam*,

Five-Quarter Seam.

These seams are sometimes known as the *Tyne* Six-Quarter and *Tyne* Five-Quarter Seams. They are distinct in the Eastern parts of the field, but coalesce towards the West of the steam coal district. Nos. 13, 12, and 11 together form the *Pontop Hutton Seam*. No. 11 is the *Low Main* of the Wear.

Strata—About 50 feet.

10. *Low Main*, or *Hutton Seam*, or *Pontop Main Coal.*—Variable in Northumberland, from 2 feet or less to 6 feet. It is the Hutton Seam of Durham, but in the South of the county is generally divided and worthless. This coal seam "is not only continuous throughout the whole extent of the Coal-field, but . . . . it also yields the *best* description of three different varieties of coal suitable for purposes not at all similar to each other—viz., the *best household* [in Durham], the *best gas*, and the *best steam coal* [in Northumberland]."[*]

Strata—Variable, from 30 to 100 feet.

9. *Plessey*, or *Crow*, or *Ryton Ruler Seam (?)*—A variable and inconstant seam, best developed in the Morpeth district,

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[*] "Industrial Resources of the Tyne, Wear, and Tees," Ed. II. (1864), p. 13.

where it is known as the Plessey Seam. It is with diffidence that it is here correlated with the seam called the Ryton Ruler in the Blaydon district. Its thickness is usually less than 3 feet.

Strata—Variable, about 80 to 150 feet.

8. *Beaumont*, or *Towneley*, or *Harvey Seam.*—About a yard in thickness. It is called the *Beaumont* in the Morpeth district, the *Towneley* in the Blaydon district, and the *Harvey* in Durham. It is the Engine Seam of Walbottle, and the Yard Seam of Cockfield.

Strata—About 20 feet.

7. *Hodge Seam.*—About 2 feet 4 inches. Only known in the Elswick and Towneley district.

Strata—About 20 feet, sometimes more.

6. *Tilley Seam.*—From 2 to 3 feet thick. Occurs in the same district as the Hodge Seam. In some places the names Hodge and Tilley are transposed.

Strata—From 30 to 45 feet, comprising in the upper part the

5. *Hand Seam.*—A thin (4 inches) but well-known seam in the Towneley district.

4. *Stone Coal,*
Strata—25 feet.
3. *Five-Quarter Coal,* } or *Busty Bank Seam.* { Two seams occurring in the Northumberland Coalfield in its Southern portions only, such as in the outliers of Whittonstall, etc., but well known on the Derwent, where they unite (as at Medomsley) to form the Busty Bank Seam, about 6 feet thick. The Five-Quarter Seam is known as the Six-Quarter Coal in the Wylam district, where the Stone Coal becomes the Wylam Five-Quarter.

Strata—About 30 to 50 feet (rarely so thick).

2. *Three-Quarter Coal*, or *Yard Seam.*—About a yard thick, best known between Wylam and Wolsington.

Strata—About 50 feet, variable.

1. *Brockwell*, or *Splint Coal*, or *Main Coal Seam.*—From 1 foot to 4 feet thick. Has been looked upon usually as the base of the Coal-Measures, but has been taken by the Government Geological Survey as the boundary line between the Middle and Lower Coal-Measures or Gannister Beds. It appears to be fairly constant throughout the district, but this may be owing, to some slight extent, to the fact that the lowest *workable* seam of any district is, *ipso facto*, called the "Brockwell."

Besides the above twenty-one principal seams there are a great number of minor beds of coal which it would serve no good purpose to enumerate. Although occasionally sufficiently thick to be profitably worked, they are not so as a rule, and are for the most part very soft. Mr. T. Y. Hall, in 1854, stated the seams then known in the Coal-field as 57, and notwithstanding the increased borings and sinkings since that date, the number is now not very much greater.

A glance at the geological map of Northumberland, on Plate I., will show that beyond the regular Coal-field extending from the Coquet to the Tyne there is a line of small detached half-basins of Coal-Measures stretching from the main mass to the West into Cumberland. This extension of the Coal-Measures was first pointed out by Mr. Nicholas Wood in 1831 in a remarkable paper, which—with Buddle's synopsis—may be said to have done more for the advancement of Northumbrian Geology than any two memoirs written before or since.* A reference to the Chapter on the Lie of the Rocks (p. 3) will show that two causes have united to bring about this arrangement—viz., first, the general flatness of the beds West of the long Corbridge fold; and, second, the disturbance of that flatness by the great Stublick Dyke. It will be seen that these little Western Coal-fields lie on the downthrow side of that dyke, and that one or two less important ones are similarly placed as regards the Western or dying-out portion of the Ninety-Fathom Dyke.

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* *Transactions of the Natural History Society of Northumberland*, Vol. I. (1831), p. 302.

Although by far the most important of the rock-divisions of Northumberland and Durham, it will be noticed that, beyond matters of detail, there is but little complexity in the Coal-Measures as there developed. From Acklington, where the Northernmost outcrops are worked, and where the correlation of the coals is not a little doubtful, through Widdrington, Woodhorn, etc., to the well-known old pit sections on the Tyne, we find (faults being left out of consideration) scarcely any change of importance affecting the series: local variations in thickness here, the splitting up of seams there, and similar accidents, although of much interest commercially, being, in regard to the distance involved, extremely small matters, geologically speaking. (See fig 1 and 2, Plate II.).

The changes that do occur are such as are common in all Coal-fields, and can all be referred to the normal conditions under which coal-bearing strata were deposited. We sometimes hear of the "swellies," or local thickenings of coal, along lines of depression—ancient Coal-Measure miniature valleys, in fact—as wonderful accidents. A little reflection will show that old land-surfaces, such as our coal floors once were, need not, according to any known law, have been of perfectly uniform level—a walk over a modern Peat-moss or swamp will show that peat has its "swellies" as well as coal—and that we must not wonder only, but observe. But if such "accidents" are to be expected they are none the less interesting on that account. The well-known "swelly" of the Low Main Seam, which Mr. Hurst has described with such minuteness and care,* is an excellent example of this heaping up of coal-matters owing to the form of the floor or thill, and full descriptions of other cases are much to be desired.

Other minor disturbing elements in the continuity of the seams are so called "stone-dykes" and "balks," which are frequent in many collieries. These are merely ancient "washes," in every respect to be compared with the washes of sub-recent and drift deposits which we have already spoken of, and from which they differ only in having filled up the valleys cutting through the denuded seams, in Carboniferous times, before or during the deposition of the over-lying beds. By mapping out the courses of swellies and "stone-dykes" we arrive at a general notion of the small features which alone seem to have broken the monotonous uniformity of the ancient flats on which the coal vegetation grew.

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* *Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. VIII. (1860), p. 23.

CHAPTER VII.

THE GANNISTER AND MILLSTONE GRIT SERIES.

THE rocks which in Lancashire and Yorkshire are conspicuous under these names are in Northumberland in nowise distinguished from the Coal-Measures proper, of which, indeed, they are simply the continuation. They comprise all those beds which lie between the Brockwell Seam and the Felltop Limestone, and like the great series described in the last chapter, consist of sandstones, shales, and coals. The last, as a rule, are thin and seldom workable. They appear, it is true, to be much less constant than is the case with the larger seams above, but not less so than the smaller ones, with which alone they should properly be compared.

The name Gannister is given to the upper portion of this division on the assumption that the beds comprised in it are the continuation or true equivalents of the well-known Gannister-bearing rocks farther South. Gannister is a local term applied to an extremely hard and very fine-grained, compact, highly siliceous kind of underclay, usually pierced through and through by a great number of fossil rootlets (stigmarian), and valuable for refractory purposes. Now, the presence of stone answering to this description in a greater or less degree in Northumberland (as at Saltwick to the South of Morpeth, and at several places to the South of Stocksfield) somewhere about the horizon at which it occurs in other districts (although the parallelism has been more than once questioned), lends force to the view that we have here, in truth, the representative of the true Gannister Series, or Lower Coal-Measures. This has been further favoured by the discovery, which I had the pleasure of making early in 1878, of a few marine fossils—including *Aviculopecten papyra-*

ceus, the Gannister fossil *par excellence*—in these beds near Whittonstall.*

With regard to the Millstone Grit, there is no reason to doubt that what is known by that term here is really the representative, or *in part* the representative, of the Millstone Grit which caps Ingleborough, Kinderscout, and so many others of the great Carboniferous hills further South.

In short, "in Northumberland the place where the Millstone Grit should be undoubtedly exists, but the grits themselves are sadly deficient both in character and thickness. Shales, shaly sandstones, and sandy shales, with a few beds of sandstones, seldom coarser in grain than many beds in the Coal-Measures, and not nearly so coarse nor so thick as some of the grits of the limestone series below—these, in considerable spreads between the Derwent and the Tyne, and in a narrow band from the latter river to the sea near Warkworth, are the component parts of the Northumbrian Millstone Grit. This miserable representative of the great hill-capping deposit further South would never have been recognised as a chief division here had Northumberland been an island, and had not the traditions of its greatness come from elsewhere. In fact, it may be affirmed that the Millstone Grit has, as it were, traded on its thickness. In Northumberland it is thin in the South, where it enters the county, and it is much thinner where it leaves it on the East Coast; it has here no lithological character which it does not share with members of the series above and below; it has no distinctive fossil remains; in short, it has nothing peculiar to it but its position."† In Durham, however, the Millstone Grit series is more important, and sundry divisions can be recognised in it, and have been mapped by the Geological Survey.

As I have stated already, there are some thin coal seams in both the Gannister series and Millstone Grit, and some of them have from time to time been worked. Ten or twelve fathoms below the Brockwell Seam a workable seam not unfrequently occurs. Thus, at Eltrincham, a valuable bed of cannel coal, about 2 feet thick, is found in this position. This is also the horizon of the coals which, in Durham, are known as the Marshall Green and Victoria Seams. In my "Outlines of the Geology of Northumberland" I stated (p. 32) that the "Crankey" Seam worked at a small colliery South of Harlow Hill, on the road to Ovingham, was in the Millstone Grit series. Mr. J. B. Atkinson, however, has since shown to me conclusively that all the seams proved in this pit are in the Coal-Measures. The presence of a hitherto unsuspected fault of large throw is necessary to account for that of the Coal-Measures at this spot.

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* See *Nature* for February, and the *Geological Magazine* for March, 1878.

† *Transactions of the North of England Institute of Mining Engineers*, Vol. XXV. (1876), p. 227.

At Harlow Hill—the lowest bed of this set of rocks—a thick, massive, yellow sandstone, flecked with rust spots, is seen to rest on what is probably the finest fossiliferous exposure of the Fell-top Limestone. This grit is the Grindstone Sill of the lead districts.

As a consequence of the small importance of the coal-seams known to exist in the Gannister beds, not many detailed sections of sinkings or borings can be referred to for details of the strata. One of the few known is a boring which was made many years ago in Chopwell Woods, on the Northern slope of the Derwent Valley, where a constant alternation of thin sandstones and shales, with worthless seams of coal in tolerable quantity, was proved to a depth of nearly 300 feet beneath the Brockwell Coal.

For many years a bed of ironstone was wrought in the upper portion of the Gannister series in the Derwent district. It was known as the "German Band"—a grotesque name due, not to any covert allusion to itinerant musicians, but to the small colony of German sword-makers who in former days worked this ironstone and plied their trade at Derwentcote and Consett.

The Millstone Grit beds are well seen at Warkworth, where the Coquet Valley exposes fine sections of them. The Wansbeck Valley likewise displays them fairly well about Mitford, a little above Morpeth. They are, however, best seen in the country lying between the Derwent and the Tyne, where, owing to the small amount of dip, they occur in wide spreads and outliers. To the North of Blanchland they can be well studied as regards their relations to the Limestone series below, the upper portion of which only occurs there. In Durham, between Barnard Castle and the Wear, are long East and West stretches of Millstone Grit. The boundaries of these, however, are often faulted. The strike of the Carboniferous beds in this district is directly at right angles to that of the Permian rocks, thus making the unconformity between the two evident on even a small scale map. (See Plate I.).

CHAPTER VIII.

THE BERNICIAN ROCKS.

THE chief peculiarity of the "Bernicians" may be said to be that, though they represent a number of divisions which in other parts of Britain and on the Continent are well and clearly defined, yet they cannot themselves be divided in any natural manner.

The series consists essentially of numerous beds of limestone, of which the thickest seldom exceed 30 feet in thickness; of grits and sandstones of every texture, from that of the coarsest grit to that of the finest-grained flagstone; of shales of every character, and of coals with and without under-clays, in every way comparable, except as to commercial importance, with those of the Upper Carboniferous series. All these beds alternate so rapidly that a complete list of them, bed by bed, if it could be accurately drawn up, would be of great length. Moreover, the value of such a detailed vertical section would be much lessened by the fact that it would only be true for the particular line along which it was measured. The thickness of the beds varies extremely from place to place, and many of them are of local occurrence only, and are frequently found to thin away and disappear very rapidly. Nor is it only the individual beds making up the series which alter so constantly in thickness, but the set of them as a whole undergoes very remarkable changes in this respect.

First, then, as to the latter point. The entire thickness of the series in the Alston Moor district—which, though strictly speaking in Cumberland, can very fairly be taken as the extreme South of Northumberland and westernmost Durham—according to Westgarth Forster is about 2,500 feet; in the North of Northumberland (the Alnwick and Scremerston district) about the same thickness was estimated by the late Mr. G. Tate;

whilst between these two regions, in the tract lying between the Tyne and the Coquet, the maximum thickness attained is at least 8,000 feet. This fact—this thickening of the Lower Carboniferous rocks in the centre of Northumberland—when once known, gives a clue to the geological structure of the county which is of great value.* As to the changes in individual beds, it would be quite out of place to give full details of such facts in a general sketch like the present; but the following truths will be confirmed by all careful observers. Having regard to the thick limestones of Derbyshire—the "Mountain" Limestone, properly so called—and the thin and rare calcareous beds contained by the corresponding series in Scotland, it might very reasonably be supposed that the Bernicians, offering, as they do, a passage from the one form or "facies" to the other, would be marked by a regular thinning and dying out of its beds of limestone. This is only partially the truth, however, for a close examination of the series will show that, although many of these beds in their trend from South to North do thin out and occasionally disappear, yet many of them maintain and even increase their thickness. Not only so, but many new limestones make their appearance. This last is a point of some importance, and is more particularly illustrated in the area of greatest total thickness already referred to. Nor are the limestones alone affected in this manner; the grits are in a very marked degree inconstant, thick crag-making beds in a short space dwindling away to nothing and being replaced by shales of equally uncertain continuity. The coal-seams likewise exhibit a much greater tendency to split up, thicken, and thin out in short distances, than they do in the Coal-Measures.

So much for the general characters of the Bernician series. Its most marked stratigraphical features may now be considered in descending order.

The topmost bed of the series is known as the Felltop

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* See Westgarth Forster's "Section of the Strata," 1829. Also G. Tate's "History of Alnwick," 1867; and G. A. Lebour "On the larger Divisions of the Carboniferous Rocks in Northumberland," *Transactions of the Mining Institute*, 1876.

Limestone, a name which is also given, unfortunately, to one or two occasional thin and impure limestones above it, in what —according to the classification here followed—is the base of the Millstone Grit. It is not often well exposed, especially South of the Tyne, but from the Tyne to the Wansbeck it is in some places quarried, and capitally seen on the North bank of the Tyne a little above Stocksfield, and at Harlow Hill in a quarry to the South of the Roman road. The latter section has been admirably described by Mr. Tate, in his "Geology of the Roman Wall, published with Dr. Bruce's large work. On the coast the Felltop Limestone seems to be represented by a fossiliferous deposit of calcareous shale, which can be collected in, at low tide only, at Foxton Hall, about a mile to the North of Alnmouth.

Between the "Felltop" and the "Little" Limestone, in the Alston district, is a thickness of some 350 feet of shales and sandstones, with no limestones. This interval in the Matfen and Inghoe district (North of the Tyne) is found to have increased to no less than 1,450 feet, and is, moreover, marked by the appearance of three intercalated beds of limestone quite as important in thickness and quality as the best of our Northumbrian limestones. These three beds form conspicuous features in the country between the Tyne and the Wansbeck, and one of them, at least, continues to the Northernmost extremity of the county. They are well seen about Belsay, and are largely quarried near Corbridge.

Accompanying this great thickening of the mass of the strata, and the intercalation of three limestones between the Felltop and the Little Limestone, there is a very obvious disproportion between the increase of the shales and that of the sandstones. In the South-West, the total thickness of the sandstones is nearly equal to that of the shales, while here the shales form scarcely one-fourth of the entire mass. Between the lowest of the intercalated limestones and the Little Limestone is about 1,250 feet in the Matfen district. This is practically made up almost entirely of sandstones and grit, often very coarse-grained and conglomeratic. At Inghoe, Shafthoe, and Rothley Crags, for instance, quartz pebbles larger than pigeons' eggs occur, and garnets have been found. These grits—which may appropriately be called the "Inghoe Grits"—were formerly generally considered as of Millstone Grit age; and it is to be noted that, as they lie above the "Great Limestone," they would be rightly so placed according to the late Prof. J. Phillips's classification, which is, however, in no otherwise applicable to the district.

Proceeding North of the Coquet, the "Inghoe Grits" thin considerably, as, indeed, is the case with most of the groups of beds which are abnormally thick in Mid-Northumberland.*

The next limestone in descending order is the "Little Limestone," an extremely constant bed, although not always easily seen, being seldom worked for lime. It can be best studied along the line of the Roman Wall, near St. Oswald's Chapel, and at Halton Shields, where it has long been quarried. It is owing to a series of faults that this bed so frequently crosses and re-crosses the Wall. From the Alston district to the Wansbeck it is well known under the name here given, but further North it receives a variety of names, such as the following:—Licker Limestone, Chirm Limestone, etc.

A workable seam of coal lying below this limestone has given it more local importance than it would otherwise have gained, and a very few feet below this coal there occurs locally in the South and North Tyne districts another intercalated limestone—a thin band, seldom visible, but exposed in the bed of the South Tyne below Allerwash, and in that of the Silly Burn, North-East of Haydon Bridge.

A variable thickness of strata, averaging about 50 feet, and usually consisting of good building sandstone (the "Black Pasture" stone of the North Tyne) and a thick shale below, separates the "Little" from the "Great" Limestone. This latter bed is perhaps the best known of any of the series, and affords a splendid geological horizon. Notwithstanding faults and occasional eclipses by Drift, this limestone can be traced with absolute certainty along the entire line of its outcrop in Northumberland and Durham. It is quarried almost everywhere along its course, and very frequently forms a distinct feature in the scenery of the country. Its fossils are better known than those of any other calcareous bed in the region, and it may well be looked upon as the type of the Bernician limestones. At Whittington, near Matfen, it is more than 40 feet thick, but further North it is thinner, averaging from 25 to 30 feet. It is known by several names along its outcrop, the principal being the "Main" and "Ten-Yard" Limestone. In the mining districts, to the West, this stratum is famous as having yielded more lead-ore than all the other beds together; and the horizontal parting between its courses mark the position most frequently occupied by those valuable lateral extensions of lead-veins called "flats." The upper part of the Great Limestone is sometimes known as the "Tumbler Beds" by the Alston miners, whilst in Weardale every thin parting has received a distinctive name.

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* See G. A. Lebour "On the Little Limestone and its accompanying Coal in South Northumberland."—*Transactions of the Mining Institute* (1875), Vol. XXIV., p. 73.

Forming a very regular line parallel to and West of that of the "Great Limestone" is the equally constant "Four-Fathom Limestone," the chief stratum between these being a massive sandstone, very much used for building purposes and known by various names. This is the "Quarry Hazle" and "Hewitson's Sill" of the mining districts, and the "Prudham stone" of Tynedale. Among the sandstones this is regarded in the Allenheads district as the richest in lead ore.

This limestone attains a thickness of 40 feet at Lippwood, near Haydon Bridge, but further North it varies from 20 to 30 feet only. It was in this limestone that the interesting Foraminifer was first found in 1868 by Sir Walter C. Trevelyan, at the Elf Hills Quarry near Scots Gap, which has since made some stir in the geological world under the name of *Saccammina Carteri* given to it by Mr. H. B. Brady, F.R.S. This organism occurs in bands in the limestone, and for some time was thought to be peculiar to it in Northumberland. It has now, however, been found at several other horizons, chiefly by Mr. W. Topley, F.G.S. in the North of that county, the Rev. W. Howchin in the Haltwhistle district, and myself in several places. Still, the limestone in question can very fairly be called the "*Saccammina* Limestone," a name which I gave to it in some of the maps of the Geological Survey, as nowhere else has *Saccammina* been yet found in such quantities or so constantly present. In the mining district of Allenheads so marked was the fossil that that portion of the limestone which contained it was commonly known to the miners as the "spotted post."*

Although the name Four-Fathom Limestone is only strictly appropriate in the Alston district, yet it is attached to this limestone for a considerable distance to the North, where it changes its name (if change it can be called) to "Eight-Yard Limestone," by which it is very generally known North of the Coquet. Its chief other name is the "Lowdean" Limestone.

The next limestone is almost as easily traceable as the two last, and is marked almost everywhere along its course by an overlying bed of shale, containing nodules of ironstone, which have from time to time been worked, but without much success. Old workings, where the fossiliferous nature of the shale can be seen, are to found along the outcrop of the bed between the Haltwhistle Burn and Bardon Mills, at Brinkburn, Lowick, etc.

The names of this limestone are somewhat puzzling, as in the South-West district it and the following bed are both called sometimes the "Three-Yard" and sometimes the "Five-Yard" Limestone. In the Northern district, however, it appears to be generally known as the "Six-Yard" Limestone. Among its other names is the "Acre" Limestone.

Another marked bed of shale—frequently fossil-bearing like that last-mentioned—caps the succeeding bed of limestone. The latter is the last of the calcareous bands which we can with safety (at present) carry from the Alston district entirely across to the sea. It has been named the Beadnell Limestone by Mr. Tate, from the place on the coast where it can be best seen; but, besides this and the names "Three" and "Five" Yard Limestone, which it bears in the Tyne district, it, like the others, is furnished with a variety of appellations, of which these are the principal:—The "Eelwell" Limestone, "Main" Limestone, "Sunderland" Limestone, etc. This limestone has been largely quarried, and is peculiar for the singular irregularities of bedding which are common in it. Some of these are well shown in the accompanying cuts.

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* I understand that since the above was written this fossil has been detected by Prof. H. A. Nicholson, of St. Andrew's, in some Scottish rocks of Silurian age. The same genus is known *living* in the Arctic regions, and fossil in some of the Glacial deposits of North America. It is also recorded from Jurassic rocks in India.

FIG. 2.—*Section in Quarry at North Sunderland.*

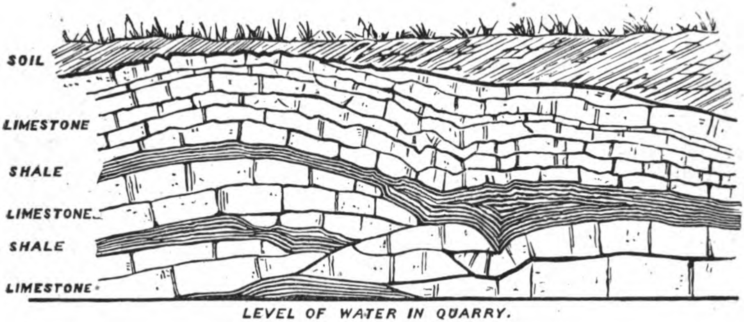
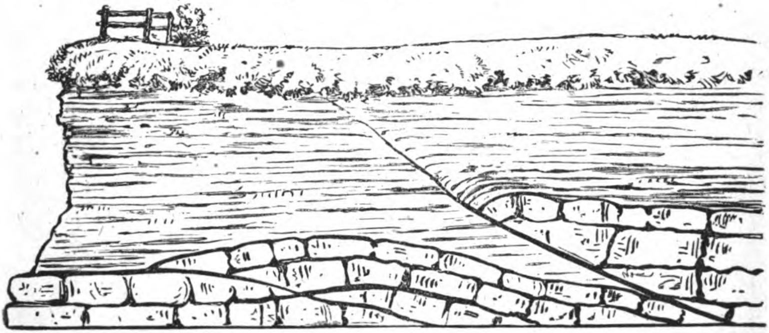


FIG. 3.—*Section in Quarry at Lowick (Eelwell), showing irregular bedding simulating reversed faults.*



Leaving out the non-continuous beds already spoken of, we have now enumerated in descending order six distinct calcareous horizons which can be clearly observed from one end of the district to the other. With the exception of the very marked local thickening of the beds in the Matfen district, between the topmost and the second of these horizons, the thicknesses of the shales and sandstones intervening between them do not vary greatly in this long distance, and the correlations are comparatively easy. But if the upper members of the Bernician series can thus be correlated from South to North with safety, this is no longer so as we descend lower down in the series. Several elements of difficulty here interfere to hinder the formation of a true comparative scheme applicable to both South and North. In the first place, a large extent of country, involving probably considerable stratigraphical changes, intervenes between the Penine escarpment—where alone the beds below the so-called Tynebottom Limestone are exposed on the South—and the Southernmost point at which they are visible in Northumberland. Secondly, when we do reach them, we find that they comprise a number of limestone beds so much greater than in the South-Western area, and with such a scarcity of distinctive features, that any attempt to follow Westgarth Forster's nomenclature is as yet hopeless. Moreover, the central district, as in the case of the Inghoe Grits, shows an immense development of the aggregate thickness of the lower beds, as well as an increased number of limestones. Thirdly, when the Northernmost area is carefully examined, although the thickness of the whole is reduced to something like its original type, and the number of limestones is once more comparable to that at Cross Fell, yet to name these beds in accordance with any system originating from a knowledge of the South-Western region would be fraught with much difficulty and almost certain failure in the present state of our knowledge.

The limestones recognised by Westgarth Forster, from the highest to the lowest, are given by him as follows:—

19. Felltop Limestone.
18. Little Limestone.
17. Great Limestone.
16. (Small Limestone).
15. Four-Fathom Limestone.
14. Three-Yards Limestone.
13. Five-Yards Limestone.
12. Scar Limestone.
11. Cockle-Shell Limestone.
10. Single-Post Limestone.
9. Tynebottom Limestone.
8. Jew Limestone.
7. Little Limestone.
6. Smiddy Limestone.
5. Limestone.
4. Robinson's Lime.
3. Melmerby Scar Limestone.
2. Limestone.
1. Lowest Limestone.

A list of the chief Coal-seams belonging to this great Limestone series in the Southern half of Northumberland (a first and probably very imperfect attempt) will now be given, and will be followed by a similar one of the better-known Northern district.

12. *Felltop Limestone Coal.*—Below the Felltop Limestone. Sometimes called the Newton Underwood Coal in the Wansbeck and Font district.

11. *Belsay, Stanton, and Netherwitton Coals.*—Below one or other of the intercalated limestones above the Inghoe Grits. Three or four seams seldom worked.

10. *Oakwood Coal.*—In the Inghoe Grits. Apparently of local occurrence only. Worked at Oakwood, near Acomb, in the Hexham district.

9. *Little Limestone Coal.*—Below the Little Limestone. In one, two, three, or even four seams. Present from the Alston

to the Berwick district. This coal is known under a great variety of names, of which the chief are Acomb Seam, Blenkinsopp Coal, Haltwhistle Coal, Clarewood, Inghoe, Boghall, and Cambo Seams. It is very often split up into two and sometimes into three seams, with occasionally as much as 50 feet between the top and bottom coals.*

8. *Great Limestone Coal.*—Just below the Great Limestone. A thin seam seldom worked, but tolerably constant. It was formerly worked at Great Whittington and in the Alnwick district.

7. *Shilbottle Seam.*—Below the Six-Yard Limestone. Present, but very thin and irregular, in the Southern half of the county. Proved at Little Bavington. Best in the neighbourhood of Alnwick.

6. *Cowden Coal.*—Below the Whin Sill. In the West Bavington district. Worked at Carrycoats.

5. *Gunnerton Coal.*—Position doubtful, but below the last.

4. *Wark Coals.*—Position doubtful, but probably near the last. The Greenlees Coal, worked formerly close to Greenlee Lough, is believed to be on this horizon.

3. *Redesdale Coals.*—Exact position in the series doubtful, but certainly low down. To this group are referred the seams known as the Stiddle Hill Coal, the Upper Hall Seam, the thin Bellingham Coals (Carriteth, Brier Edge, etc.), the Elsdon Seams (Andrew's Close, Soppit, etc.), and those worked at Hareshaw Head and Brownlees. The correlation of these seams is a matter of great difficulty, and some years' constant attention to the subject in the field has thrown but little light upon it.

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* See Lebour "On the 'Little Limestone' and its accompanying Coal in South Northumberland."—*Transactions of the North of England Institute of Mining Engineers*, Vol. XXIV., p. 73.

2. *Plashetts Coals.*—Below the Dun Limestone and the Piper's Cross Limestone (sometimes called the Papist's Cross Bed). This group consists of three chief workable seams, viz.:—

a.—*Plashetts Coal.*—This seam is immediately overlain by a richly fossiliferous marine band.

b.—*Greeneyes Seam.*—Separated from the last by the Greeneyes Crag Sandstone.

c.—*Shilburnhaugh Seam.*—Separated from the last by a great thickness of rapidly alternating shales and sandstones, the former largely predominating, and full of fossil Entomostracans. This coal is of excellent quality, and has long been worked for landsale purposes.

Above *a* is a seam known as the "Thirty-inch Coal," which has been worked in places in a very small way, and between *b* and *c* comes another thinner seam which has been worked at Starslee.

1. *Lewis Burn Coals.*—These are separated by a considerable thickness of rock (chiefly massive sandstones with interbedded thin ripple-marked flaggy and impure limestones) from the Shilburnhaugh coal horizon. The coals are more splint-like than most of those already named, and where they are best seen—in the Lewis Burn Valley—they are disturbed and dip at very high angles owing to numerous faults.

The following is a list, in descending order, of the Bernician Coal-seams which have been worked in the North of Northumberland, beginning with the Little Limestone Coal:—

12. *Little Limestone Coal.*—Below the Little Limestone. In three or even four seams, known as the Parrot, the Rough, the Licker, and the Chirm Coal. The Rough and Licker seams are those chiefly worked.

11. *Great Limestone Coal.*—Below the Great Limestone. Called the Dryburn Coal. Very variable in thickness and seldom worked, except in the Lowick district.

10. *Shilbottle Coal.*—Below the "Six Yard" Limestone. Called also the Acre Coal. It is very variable in quality and thickness, and is best at Shilbottle. Tate says that *there* "it is the best coal in the Mountain Limestone formation."

9. *Beadnell Coals.*—Below the Beadnell Limestone. Two seams, of which the lowest attains a thickness of 6 feet. This is known also as the Eelwell Coal.

8. *Oxford Limestone Coals.*—Below the Oxford Limestone. Four principal seams, viz.:—

a.—The *Greenses*, *Allerdean*, or *Swinhoe Coal.*
b.—The *Muckle Howgate*, or *Fleetham Coal.*
c.—The *Little Howgate Coal.*
d.—The *Upper Scremerston Main Coal.*

7. *Dunstone Coals.*—Below the Dun Limestone. Three seams, of which the two lower are the most important, and are still worked, viz.:—

a.—*Raby's Coal.*
b.—*The Fawcett* or *Caldside Coal.*—This seam is looked upon in the district as lying usually 40 fathoms below the Hobberlaw Limestone.

6.—*Blackhill Seam.*—Reckoned as being about 90 fathoms below the Little Howgate Coal. This seam is also named the "Scremerston Main" and the "Craw" coal.

5. *Hardy Coal.*—2 or 3 fathoms below the last. Sometimes in two seams, when the upper is called the Hardy, Stony, or Kiln Coal, and the lower the Diamond Coal.

4. *Bulman Coal.*—5 fathoms below the last. Called also the Cancer, or Main Coal.

3. *Three-Quarter Seam.*—About 18 fathoms below the last.

2. *Cooper-Eye Coal.*—3 or 4 fathoms below the last. Known also as the Stony or Lady Coal. A very variable seam, formerly worked at Eglingham.

1. *Wester Coal.*—From 10 to 12 fathoms below the last, and the lowest worked coal of the series.

The table now given is an attempt at a correlation of the horizons of the Bernician series from South to North, as indicated by the coal seams:—

SOUTHERN DISTRICT.	CENTRAL DISTRICT.	NORTHERN DISTRICT.
Crow Coal, or Upper Coal Sill	Felltop Coal.	———
———	Belsay Coals.	Netherwitton Coal.
———	Oakwood Coal.	———
Little Limestone Coal, or High and Low Coal Sill	Little Limestone Coal	Parrot, Rough, & Licker Coals, Chirm Coal.
———	Great Limestone Coal	Dryburn Coal.
———	Shilbottle Coal	Shilbottle or Acre Coal.
———	———	Beadnell Coals.
———	Cowden Coal Wark Coals Redesdale Coals	Oxford Limestone Coals.
Coal below Melmerby Scar Limestone (?)	Plashetts Coals (?)	Dunstone Coals. Blackhill Seam. Hardy Seam. Bulman Seam.
Lowest Seam (?)	Lewis Burn Coals (?)	Three-Quarter Seam. Cooper Eye Coal. Wester Coal.

Besides the Limestones and the Coals, to which, by reason of their importance, we have devoted considerable space, there are still to be noted the much thicker Sandstones and Grits, which, with the Shales, make up the rest of the great Bernician series. As might be expected from what has been already said, they are by no means constant over great distances, and in a sketch of this kind a detailed account or list of beds of sandstone would be obviously out of place. There are, however, three great groups of grits which may be traced with ease over a large proportion of the county, and which, as they contribute very strongly to the leading features of its scenery, must not be passed over. These are:—

3. *The Inghoe Grits.*—Lying high up in the series, between the Felltop and the Little Limestone, and attaining their greatest thickness—as has been explained before—in the Inghoe district, between the Tyne and Wansbeck. They it is that form the bold, coarse, sandstone hills, sloping with the dip towards the former river, on its North bank, between Corbridge and Fourstones, and again between Bardon Mill

and Haltwhistle. Occasionally interbedded among the grits are fine-grained and sometimes flaggy sandstones, in places rich with the casts of marine shells. The bands of shale which occur in some number are quite subordinate to the arenaceous beds.

To the South of the Tyne, the "thick-grit" character of this series merges into that which belongs to it in the Alston district, where it is chiefly marked by two well-known beds—the Whetstone Sill, a fine-grained, and "Pattison's Sill," a tough sandstone.

2. *The Rothbury Grits.*—This thick series of grits was first described by Mr. Topley, F.G.S.* They form the very conspicuous Simonside Hills, which rise to a height of nearly 1,600 feet on the South side of the Coquet, near Rothbury. This is perhaps their greatest development, as they decline in thickness and feature-making power both to the North and to the South of that point. To them belong the range of crags running from Rothbury to Callalee on the one hand, and those from Simonside, on the East side of Billsmoor Park, to Hartside Pike, near East Woodburn, and the Wanney Crags, just South of the Wansbeck Valley Railway. Thence across North Tynedale, and ranging North of and parallel to the line of the Roman Wall, their crag-like character is kept up under very numerous names. But the shales and limestones between the individual grits assume a greater importance, to the detriment of the grit-like nature of the group as such, Indeed, names like those which are here adopted to distinguish the grit ranges must only be regarded as convenient for special districts. They do not correspond with definite natural divisions, holding good over considerable distances; and the constant thickening and thinning of the grits themselves, which may be likened to a kind of Cyclopean false bedding, prevent the tracing of the component members of each group separately.

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* See Geological Chapter in the "Guide to Rothbury and Upper Coquetdale,' Alnwick, 1873. Reprinted in a second edition of the "Guide" in 1874.

1. *The Harbottle Grits.*—This group is apparently only clearly defined in the region whence its name has been taken. There (around Harbottle, on the upper Coquet) we have a mass of grits comparable in total thickness, lithological characters, and in the constantly-varying thickness of the beds of which it is formed, with the Rothbury grits. Their upper limit is tolerably well defined by means of the lowest of a set of thick blue limestones of the ordinary Bernician type crossing from Redewater into Coquetdale, on the high moors between Grasslees and Horsley or Rochester. The base-line is still better defined in this locality, as the grits on the south side of the Coquet between Holystone and Linnsheeles immediately overlie thin bedded shales and cement stones of obvious Tuedian aspect. The Harbottle Grits are thick in this, the typical tract, where they form the Beacon and the Drake Stone Hills, but become thicker still as they spread out to the West and South-West, forming the great sandstone crags which stand out like the tiers of vast amphitheatres at the head of Rede and North Tyne. To this group must be referred the Countess, Ellis, and Christenbury (?) Crags, and also the Peel, Deadwater, and the greater part of the Carter Fells.

This great bottom Bernician group enters the county from Cumberland, near the head of the Irthing, and from Scotland, along the Liddellwater, and thence to the Coquet, its presence is made splendidly manifest in some of wildest mountain scenery to be found along the border. Seldom falling below the 1,000 feet contour-line, and frequently approaching that of 2,000 feet, it rises far above boulder-clay and drift, with a very low and rolling dip which, with several large repeating faults, helps in a great degree to multiply the extent of its craggy outcrops.

These beds, although the lowest in the Carboniferous Limestone series, where, too, this series is of a great and almost abnormal thickness, have sometimes been, like some others already referred to, regarded as Millstone Grit—chiefly, it is presumed, because some beds in it, as, for instance, that to which the great semi-boulder known as the Drake Stone belongs, have been used for the manufacture of millstones! No better proof could be found of the misleading tendencies of lithological names when applied to stratigraphical groups.

To the North of the Coquet the characters of the Harbottle Grits are, to all appearance, gone. Whether the detailed working out of the beds, now proceeding in that part of the county, will explain this, I know not, but that a very material change does take place is very evident. Either a bodily thinning out occurs here on a very large scale, or the nature of the beds change, as there appears to be no reason to suspect a fault or faults so great as to produce the effects observable. The "almost sudden thinning out" theory seems the most probable, as it would account, not only for the state of things in the northernmost part of the county, where no group on such a scale as this one is to be found, but also for a curious and otherwise unexplained series of very high dips which are to be found in the adjoining and over-lying Rothbury Grits.

I have left the above descriptions of the Rothbury and Harbottle Grits almost exactly as they stand in my "Outlines of the Geology of Northumberland" (except that I have substituted Rothbury for Simonside which was a mistake) because they seem to me to give a fair account of these rocks. It will however be seen that, even in 1878, I was by no means dogmatic as to the relations which these great grit-masses bore to one another. A little later I recurred still more doubtfully to the subject,* and pointed out that some very high dips in the Grasslees Valley, near the Beacon Hill, were evidence of a disturbance which might prove to be the key to the puzzle. I believe that now, in the skilful hands of Mr. Hugh Miller, of H.M. Geological Survey, the difficulty has vanished, and that the Rothbury Grits and the Harbottle Grits must now be regarded as the same series repeated by a large fault. Under these circumstances the name "Harbottle Grits" will probably have to be given up or be used only as a convenient topographical expression, since Mr. Topley's "Rothbury Grits" has undoubted precedence. Dr. A. Geikie's term, "Fell Sandstones," though a good one, was published too late for adoption.

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* See Lebour, "Notes on the Geology of the Country round Elsdon," in the *Berwickshire Naturalists' Transactions.*

As will be seen presently, the Rothbury Grits may come to be claimed—as, indeed, they have been already—as the upper members of the Tuedian series. (See *post*, p. 78.)

Before closing the present Chapter, it may be necessary to say a word as to the term "Bernician" which heads it. The late Dr. Samuel Woodward first used it in his "Manual of the Mollusca" (1856), as the equivalent of "Lower Carboniferous." It seems then to have been forgotten for years, until, about ten years ago, I revived it with a slightly different signification, namely, as expressing the peculiar character or type of formation exhibited by the Carboniferous Limestone series in Northumberland, that is, in ancient *Bernicia*.* Thus the term "Mountain Limestone" is suitable to the purely calcareous, and the term "Kulm" to the purely argillaceous facies of the Carboniferous Limestone series, whilst Bernician is applied to the mixed type which is most fully represented in the Border counties.

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* See Lebour in the *Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. XXV. (1876), and *Geological Magazine*, Decade II., Vol. IV. (1877).

CHAPTER IX.

THE TUEDIAN AND BASEMENT BEDS.

ALONG the Penine Escarpment, in Westmorland, the Carboniferous Limestone series rests upon a very well-marked set of rocks, to which Mr. Goodchild, F.G.S., has given the appropriate name of Roman Fell Conglomerates. These again rest upon another quite distinct mass of Conglomerates, generally known now as the Basement Beds of the Carboniferous Rocks but formerly regarded as Old Red Sandstone, which lie unconformably upon Silurian beds.

In Scotland the Carboniferous Limestone series rests upon what Maclaren in 1839 called the Calciferous Sandstone series, a division which Dr. A. Geikie, F.R.S., describes as follows:—"The Calciferous Sandstone series is composed of two groups of strata, the lower of which—or Red Sandstone group—consists of red, white, and yellow sandstones, blue, grey, green, and red marls or clays, while the upper, or Cement-stone group, is made up of white and yellow sandstones, blue and black shales, thin coals, seams of limestone and cement-stone, and abundant volcanic rocks. The red sandstones pass down into the Upper Old Red Sandstone, with which indeed they might be classed, and from which they differ merely in the less intensity of their colour, in the frequent grey and purplish tints they assume, and in the absence of the deep brick-red marls so marked in the Upper Old Red Sandstone."* I may remind the reader that the Upper Old Red of Scotland lies unconformably upon the Lower.

In Northumberland, as indeed might be expected, the Carboniferous Rocks beneath the Bernician series partake to some extent both of the Penine and Scottish characters. The Roman Fell Conglomerates are absent as such, but the Basement Beds are present, whilst the Calciferous Sandstone series, though not divisible into two groups, is well represented by beds which, from their excellent development on the banks of the Tweed, were termed Tuedian by the late Mr. George Tate, of Alnwick, in 1855. There is here, however, so perfect a passage between the Basement Beds and the Tuedians that in this work both will be treated under one head. No hard-and-fast line can, therefore, be drawn either at the base or at the top of the Tuedian series; but, notwithstanding this, the beds of that division have most of them a distinct character of their own. The sandstones—of which they consist to a considerable extent—are not unlike those of the Bernician, except towards the base of the series where they often contain rolled fragments of Cheviot porphyrites, these fragments increasing in size as we get closer to the parent mass and being accompanied by a deepening brownish-red tinge. This is well seen at Biddlestone, where, in the burn running behind the Hall, an excellent section, showing the change from the mere coarse yellow sandstone of the ordinary Tuedian to the dark-coloured conglomerates of the Basement Beds, is very marked. Still better can this be studied in the fine section at Roddam Dene, where the porphyritic conglomerates are splendidly exposed. Smaller and less clear sections, showing this bottom character of the series, are to be found at other localities on the flanks of the Cheviots, and in all cases these coarse reddish rocks have been looked upon as Upper Old Red Conglomerate. It seems, however, much more philosophical to hesitate before drawing a line between these red rocks and a series which is—as the recognised Tuedians undoubtedly are—in every respect simply an undisturbed continuation of them. The entire mass is, therefore, here called Tuedian. Adopting this course, then the lower limit of the Tuedians in Northumberland is defined by the outline of the Cheviot rocks which had long been erupted and stood as an island in the lowest Carboniferous or Upper Old Red Sandstone sea. The upper limit is not so easily traced—indeed in many cases it cannot be traced at all. Convenience and expediency have, however, determined the choice of certain beds at various points as defining the top of the series; but it must be borne in mind that the line thus obtained is purely arbitrary, and that a *true* boundary separating Tuedian from Bernician rocks would not keep to any one horizon, but would be represented by a zig-zag line, the accurate delineation of which would demand a perfectly accurate knowledge of the minor details of the beds such as there are no means of obtaining until the maps and memoirs of the Geological Survey relating to this district are published. In practice the Tuedian rocks are said to begin (proceeding downwards) where the *limestones* of the Bernician series lose their usual Carboniferous Limestone type—where they become cream-coloured, hard, unfossiliferous, and magnesian, and where they assume the character of cement-stones.

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* See Geikie's "Text Book of Geology" (1882), p. 739.

Too much weight must not be attached to the character of the fossils in the limestone for purposes of stratigraphical classification, since, as is well known, there occur in the West of Scotland, among Red Sandstones yielding Upper Old Red Sandstone fishes, bands of limestone full of corals and shells of common Carboniferous Limestone species.*

To the North of Berwick, the lowest accepted Bernician Limestone is the Dun Limestone, well known throughout the Northern part of Northumberland. This is the limestone which crops out for some miles along the coast at Lamberton. Though thin, it is extremely rich in the ordinary fossils of the Limestone series and in small Gasteropods. This has been taken by the Scotch Survey North of Berwick, and by Mr. E. F. Boyd, F.G.S., South of the Tweed, as the line separating Bernician from Tuedian, and for that region it may well be adopted here.† But in the Upper Coquet district, where the Tuedians are very well developed, no such limestone can be traced, and the Rothbury and Harbottle Grits, already described, are so thoroughly Bernician in facies, and so well divided stratigraphically from the Tuedians, that *there* the base of this great Sandstone series forms quite the most convenient boundary line. Now, there is little doubt that the horizon of the Lamberton or Dun Limestone is *above* the Harbottle Grits, so that the merely expedient and artificial character of the boundaries thus arrived at is shown at once. The truth is, that no line should be drawn at all, except as the merest matter of convenience.

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* See Geikie, *op. jam. cit.*, pp. 716 and 739.

† The Rev. W. Howchin, F.G.S., of Haltwhistle, has kindly searched some washings of this interesting bed for me, and has framed a valuable list of its microzoa. (See list of fossils in the Palæontological Chapter.)

An awkward result of the above-described state of things is this: The Rothbury and Harbottle Grits, and the great Grit series to the West of Chillingham, are probably the same; at any rate, they are not far separated in age. In both these deposits the remains have been found of a shell which is characteristic of the Yellow Sandstone series (= Tuedian) of Ireland—the *Anodonta Jukesii.* Hitherto, this shell has not been found elsewhere in England.* Had the line we have taken been anything but confessedly an artificial one we should have been compelled to explain the occurrence of this eminently *Lowest* Carboniferous fossil both above and below that line; but, as it is, there need be no real difficulty about the matter. A more or less broad margin must be allowed on either side—true passage beds, in fact—which may be said to belong, and do actually belong, to both Bernician and Tuedian. The discovery of *Anodonta Jukesii* in the lowest Bernician does not necessarily affect its Tuedian—in this case *Upper* Tuedian—character.

Cement-stones (as are all the Tuedian Limestones, more or less) are very frequent in the series, but they do not appear to be at all continuous, although tolerably thick in places.†

They can be well studied in Upper Coquetdale, where (as at

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* See R. Howse, *Natural History Transactions of Northumberland and Durham,* Vol. VII., Part I., p. 173. The first notice of this occurrence was published by Mr. Howse in the *Newcastle Daily Journal.* See also Prof. W. Boyd Dawkins, F.R.S., "On the Range of *Anodonta Jukesii.*"—*Transactions of the Manchester Geological Society,* Vol. XVI. (1881), p. 247.

† See Lebour's "Mineral Resources of the Country between Rothbury and Wooler."—*Transactions of the Mining Institute* (1882).

Alwinton, Biddlestone, etc.) they have at times been burned for agricultural purposes, although they are not very well suited for the purpose. No fossils have, to my knowledge, been found in these calcareous beds. At Hetchester, near Hepple, on the Coquet, several beds of limestone are worked, the exact position of which is doubtful. There their character is entirely Tuedian, and they are peculiar in lithological structure. They are minutely oolitic—that is to say, composed of small round or oval many-coated concretions of a more or less silicious nature, or cherty—and they are exceedingly hard.

Besides the limestones, the shales and sandy clays of the Tuedians are decidedly characteristic. The former are very commonly purple, and the latter greenish, thick, occasionally marly, and full of hard amorphous silicious concretions; they are well shown about Holystone and Sharperton. Some small ill-shapen Brachiopods, belonging apparently to the genus *Athyris*, and some large but very imperfect specimens of *Nautilus*, have been found in the shales at the Barrow Scroggs on the Upper Coquet. Other marine fossils have since been found in the Tuedians of Northumberland, in the neighbourhood of Pow Burn and elsewhere, but they are very rare. The sandstones abound in Sigillarian and Lepidodendroid remains, with a few Calamites. The genus *Ulodendron* appears to be especially plentiful in these beds, and is common at the *Anodonta* horizon.

Patches of Lower Carboniferous rocks, chiefly sandstones of Tuedian age, are seen here and there resting undisturbed on the flanks of the Cheviot Hills on the Porphyrites, as along the Clennell Street, an old mountain road running from Alwinton to the Border. Such preserved shreds of the ancient covering of the lower slopes of the *Massif* are interesting, and help to prove its age. (See Plate IV., Fig. 2.) Other patches of sandy beds associated with the Porphyrites, of which I have no personal knowledge, are, I am told, regarded as being of Lower Old Red Sandstone age.

The volcanic rocks which have already been mentioned as occurring in the Scottish Calciferous Sandstone series just enter Northumberland at Carham.

In Durham, the Tuedian beds proper are nowhere seen, but a very thin and non-characteristic representative of the Basement Beds may be present in Teesdale, where the Carboniferous series is seen to lie upon a floor of denuded Silurian below the High Force.

Before leaving the Carboniferous system, which forms so large and important a portion of England North of the Tees, it may be not unadvisable to recapitulate briefly the relations which the divisions adopted in this work bear to those usually recognised elsewhere. This object will be best attained by means of a comparative table showing side by side the classifications in use in various parts of Great Britain.

N.B.—In this table no attempt has been made to represent the relative thickness of the subdivisions.

[*See next page.*]

Bristol District.	Derbyshire.	Craven.	Cross-Fell.	Bernicia (Northumberland and Durham).	Scotland.
U N C O N F O R M I T Y.					
Upper Coal-Measures. Pennant Grit. Lower Coal-Measures.	Coal-Measures.	Coal-Measures. Gannister Beds.	*Denuded.*	Coal-Measures. Gannister Beds.	Coal-Measures. ?
Millstone Grit.	Millstone Grit.	Millstone Grit.	Millstone Grit.	Millstone Grit.	Moor Rock.
Upper Limestone Shale.	Yoredale Shales.	Yoredale Rocks.	Yoredale Rocks.	Bernician. *Rothbury Grits.*	Carboniferous Limestone Series.
Mountain Limestone.	Mountain Limestone with Toadstones.	Scaur Limestones.	Melmerby Scar Series.		
Lower Limestone Shale.	*Not exposed.*		Roman Fell Conglomerates.	Tuedian.	Calciferous Sandstone Series.
Old Red Sandstone.	*Not exposed.*	Basement Beds.	Basement Beds.	Basement Beds.	Upper Old Red Sandstone.

CHAPTER X.

THE SILURIAN ROCKS.

WITH the possible exception of the so-called Lower Old Red sandy patches already referred to (see p. 79), the oldest post-Silurian sedimentary rocks of Northumberland and Durham are Carboniferous. The Silurian deposits themselves, though probably everywhere present at a certain depth, are seldom exposed, and then only as inliers due to the denudation of the overlying beds.

In Northumberland, greywacke grits and shales are seen occupying the valley bottoms about Whitelee in upper Redewater, within two or three miles of the Border, and at Makendon, in a corresponding situation in the wildest reaches of the Upper Coquet (see *ante*, p. 4). In another portion of the Cheviots, at Fawdon Burnside near Ingram, similar shales or clay-slates were detected some years ago by Mr. Topley, of H.M. Geological Survey.

In Durham, Silurian rocks are only known at Pencil Mill, near the High Force, in Upper Teesdale, where they were first recognised as such by Messrs. Clough and Gunn, of the Geological Survey.

The above four localities are the only ones known to me at which such rocks have been observed within the region under description, and they none of them offer very satisfactory evidence as to their exact age. The largest of these inliers—that of Whitelee—probably belongs to the Riccarton series, which, chiefly on the strength of the Graptolites found in it on the Scottish side, is regarded by Professor Lapworth as the equivalent of the Wenlock Beds of Wales. A few rare specimens of Graptolites found on the English side corroborate this view. At none of the other places mentioned have fossils been found, and though the Makendon and

Fawdon Burn beds probably belong to the same group as those at the Carter foot (Whitelee) yet no certain statement can be made as to their age.

The rocks of the Teesdale section, though unfossiliferous have been referred to the horizon of the Pale Slates of the Lake District on what cannot but appear rather slender grounds.

CHAPTER XI.

IGNEOUS ROCKS: DYKES.

WHEN the "Outlines of the Geology of Northumberland" appeared, in 1878, little was known respecting the microscopical structure or chemical composition of the igneous rocks of the North of England. Since then, however, they have been examined petrologically by Mr. J. H. Teall, M.A., F.G.S., whose researches in this department, though so recent, have already become authoritative. The reader is referred, therefore, for petrographical details to Mr. Teall's papers.*

The igneous rocks of Northumberland and Durham are of many kinds, but they can conveniently be grouped under five heads, viz.:—

1. Basaltic Dykes, some probably of Tertiary age, others Permian or Triassic.
2. Sheets and Bosses, of post-Carboniferous but probably pre-Triassic age.
3. Porphyrites, Granites, etc., of post-Silurian but pre-Carboniferous age.
4. Felsitic rocks of Tuedian age.
5. Mica-trap Dykes, probably of Silurian age.

1. *Dykes.*—These, with one or two rare exceptions, are remarkably uniform in lithological composition. They are, as a rule, close-grained Basalts (or plagioclase-augite rocks with very little and sometimes no Olivine), deep blue when freshly broken, with strong conchoidal fracture, weathering to brown and red, and very commonly into spheroidal balls. It would

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* See "Petrological Notes on some North of England Dykes."—*Quarterly Journal of the Geological Society* (1884), p. 209; also "Petrographical Notes on some of the Igneous Rocks of Northumberland," in the *Proceedings of the Geologists' Association* for 1886.

not answer any useful purpose to enumerate all the dykes known, but a few of the more remarkable must be mentioned. The bearings of the dykes are many, but a very large majority run in two main directions, one set being East and West or South-East and North-West, and the other, roughly, North-East and South-West. The former appear to belong to the same category as the numerous Tertiary dykes which follow parallel courses across the South of Scotland; one of them, indeed—the Acklington Dyke—being doubtless merely the South-Easterly continuation of one of these Scottish dykes The reasons for considering the latter as of Tertiary age have been worked out with great success by Dr. A. Geikie, Mr. Jack, and others, and there seems to be none to urge against their application to some, at least, of those South of the Tweed. The supposed Triassic age of some of the dykes requires proof.

The dykes vary greatly in width, that at Holy Island being the thickest on the whole, although others sometimes attain locally an equal breadth.

Most of the dykes are single, so far as they are known to me; but a few are proved to split up into branches, whilst others are suspected of doing so.

In a few cases the dykes are seen to overflow laterally. The Acklington Dyke, for instance, as it approaches the Cheviot Porphyritic mass, through which it cuts, spreads irregularly over the beds of Tuedian age in which it is encased. This is very beautifully seen along its course from a little to the South-West of Biddlestone to the banks of the Alwin, at Clennell. The Cockfield Dyke also overflows at Bolam, in South Durham. At Shilbottle, two "beds" or "sheets" of whin are known, which *may* be lateral dyke-overflows of a similar character, but which have also been referred to the Whin Sill. Sir Lowthian Bell, Bart, F.R.S., has published a very interesting paper on the composition of the basalt of the overflowing limbs of other dykes near their junction with the surrounding sedimentary rocks.*

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* *Proceedings of the Royal Society* (1875), Vol. XXIII., p. 543.

Some of these dykes, which are well known through having been met with in underground workings, do not reach the surface at all, and many which are seen "to the day" do not continue at so high a level for any distance. In some rare cases the actual natural *top* or vertical dying out of a dyke can be seen, as on the coast a little to the South of Seaton Sluice. Here, near the Collywell spring on the beach, a dyke, at least 12 feet in width where it rises at the foot of the cliff, is finely shown, ending off in two tongues of basalt, the longest of which, after curving amongst disturbed and contorted shale, dies out about 11 feet from the ground beneath a bed of sandstone, which it had not the force to break through. The fault along which this dyke was injected is well seen continuing its upward course. A more instructive section it would be difficult to find. The same dyke is also seen in Holywell Dene, a little inland.

The Cleveland Dyke is of special interest, since it is the only one in Northumberland or Durham which actually cuts through post-Palæzoic rocks. It is worked among the Jurassic beds of the Cleveland Hills, and thence crosses a considerable portion of South Durham, receiving various names along its course. It possesses, also, sundry petrological characteristics peculiar to itself.

The Hett Dyke is another well-known Durham dyke.

The dyke which crosses the Wansbeck a few yards below the viaduct of the North-Eastern Railway is much more largely crystalline and blacker in colour than is usual. It contains, according to Mr. Teall, more Olivine than any of the others. The Acklington Dyke seems to be usually more or less vesicular and amygdaloidal, a character which does not appear to belong in any marked degree to other Northumbrian dykes. The Tynemouth Dyke, where it is seen by the side of the Pier in the Priory Cliff, was always in former days described as consisting of greenstone, and certainly its appearance at that point is different from that of the ordinary dykes. Microscopically it has revealed several peculiarities of structure and composition.* It was formerly only known here, where it is seen to cut through the Yellow Sandstone, its relation to the Magnesian Limestone being unknown. In 1873, Mr. Favell, F.G.S., detected the prolongation of this dyke to the West, near Billy Mill, and the specimens which I have seen from that locality do not differ (to the unaided eye) from some taken from the common basaltic dykes. Mr. Teall informs me that the dyke was exposed during the construction of the new railway station at Tynemouth. Winch remarks that this whin is very like that of Coaley Hill, and a recent exposure of the latter at Walbottle enables me to confirm that observation.

Of the other dykes, the following are some of the more important:—

A.—*East and West Series.*

The *Hebburn Dyke*, emerging from beneath the Magnesian Limestone near Cleadon, runs by Hedworth and Hebburn, crosses the Tyne and enters Northumberland at Walker, thence by Byker through Newcastle, along the Southern margin of the Town Moor as far as Slatyford, where it meets the Ninety-Fathom Dyke. For a space it no longer reaches the surface, but re-appears in its original direction as the well-known Coaley Hill Dyke, between Whorlton and Dewley, near to which place it is finally lost sight of; it is true that the petrological testimony does not seem to be in favour of this view, but too much weight must not be attached to it at so great a distance, unless it be corroborated by other facts. This dyke is confined to the Coal-Measures, and the fact that it does not penetrate the Magnesian Limestone at Cleadon has been made use of as an argument to establish its pre-Permian age. This evidence is, however, purely negative, and standing alone, as it does, cannot be considered of much weight. On the beach, at Whitburn, are a very large number of basalt boulders. It is thought that possibly they betoken the passage of the Hebburn Dyke at this spot.

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* See Teall in *Proceedings of the Geological Association* (1886).

The *Cramlington, Bedlington,* and *Lower Wansbeck Dykes* comprise some half dozen parallel lines of intrusion, which are marked by branches of an unusual character.

The *Acklington Dyke,* which has already been mentioned, stretches across the entire width of Northumberland from the coast at Bondicar, near Acklington, cutting through Coal-Measures, Millstone Grit, the whole of the Bernicians, the Tuedians, and Cheviot porphyrites. As stated before, it runs on for many miles across the South of Scotland. It is well seen at numberless places along its course, notably at Debdon, Cartington Castle, Clennell (where it overflows laterally), and the road along the Coquet near Shillmoor. At Acklington it is 30 feet wide.

The *Trobe's Dene Dyke* appears only underground in the eastern part of the Shilbottle Colliery, running nearly from East to West.* It is from this dyke that the lateral overflows of basalt mentioned above in connection with this locality are supposed to proceed.

The *Beadnell Dyke,* well seen on the coast at the place of that name, is remarkable for the hæmatite with which it is associated. It does not fault the beds, and is "traceable as ar as Newham Station." (Tate.)

The *Holy Island* or *Lindisfarne Dyke,* the last of the more important dykes belonging to the East and West series, is thus described by Mr. Tate:—"It is one of the largest in the county, and indeed has been erroneously described as part of the Whin Sill, to which it has some resemblance, as it rises in Lindistarne or Holy Island in high craggy hills of columnar basalt. It crosses the southern part of the island nearly from West to East, and is seen two miles seaward forming the Plough and Goldstone Rocks, on which the "Pegasus" was wrecked. The Castle crowns a high craggy basaltic hill, and on the West side of the island the dyke is exposed in a high cliff, and is there 120 feet wide, with a slope 85° Southward; large blocks of limestone, highly metamorphosed, are enveloped in the basalt, and the strata, broken through, have been relatively altered in position, those on the South side having been considerably upcast. A calcareous shale, very fossiliferous, and a limestone beneath it, abut against the dyke and are metamorphosed; and, near to the Castle, a vein of basalt penetrates the shale. This dyke is seen near Fenham on the mainland, and further Westward near Kyloe Church, where its width is from 20 to 60 feet, for it widens as it descends; in one part it is covered by shattered beds of shale. It cuts through the Lowick coal-beds, and is traceable further Westward to Leitham, the whole ascertained course being about 14 miles."*

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* G. Tate, F.G.S., *Proceedings of Berwickshire Naturalists' Club* (1863), p. 211.

Many small dykes known at various places in the West and centre of Northumberland, in the Bernician area (as at Hareshaw, Wark's Burn, etc.), belong to the same series as those above-named (by their direction), but, as will be presently seen, the chief dykes of this region belong to the second category, viz.:—

B.—*North-East and South-West Series.*

The *Brunton Dyke*, known in West Allendale, near Whitfield, crosses the South Tyne—first to the West of Haydon Bridge, then between that little town and Wharnley, and lastly to the East of the latter place: it crosses the North Tyne near Wall, is well exposed by St. Oswald's Chapel near Brunton, and is last seen in the Bingfield Burn, on the East side of the Watling Street. Two small dykes run close and parallel to this one near its Easternmost extremity, and have sometimes been mistaken for it. Of these, one is well seen in the Bingfield Burn, and the other in the bed of the Pont, where that little stream crosses the Watling Street.

The *Bavington Dyke* begins almost due North of the spot where the last dyke ends, and is quite parallel to it in direction. It is of great but irregular thickness where it is first seen, just South of the Bavington Hall grounds, so much so that it might be taken, at first sight, for the Southern continuation of the Eastern branch of the Whin Sill, but it very gradually thins away in its North-Easterly course to a yard or less. It is well shown at Bolam (the Northumberland village of this name) in the Park, and is visible in the bed of the Pont below the Coal-House Quarries.

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* *Loc. cit.*, p. 210.

The *Lewis Burn* or *Trough-End Dyke* is first seen in Northumberland in Short Cleugh, a little valley formed by a tributary of the Lewis Burn; thence good exposures are frequent, as in the railway cutting East of the Belling, crossing the Tarret Burn at High Green, in the field just North of Troughend Hall; in the Elsdon Burn between Elsdon and High Carrick, on the road from Elsdon to Billsmoor; and, lastly (and, perhaps, best of all), in a deep cleugh in the high hills between Billsmoor Park and Darden Lough, whence it has been traced to the South of Tosson, as I am informed by Mr. Topley. This dyke is sometimes—very inappropriately—called The Falstone Dyke.

The *Black Burn* or *High Green Dykes* are two or three in number, and occur exactly parallel to and within a short distance of the last dyke, to the North. They are well seen in the Black Burn, which runs into Tarret Burn, but have not yet been traced any distance. These, together with the Trough-End Dyke, are what Mr. Teall calls the *High Green Dyke*, which he notes as being strikingly like the Great Whin Sill in structure and composition.

The *Plashetts Dyke* (already referred to at p. 8) is of uncertain direction, although in a general way it may claim to find a place in this series. It forms the Eastern boundary of the Plashetts coal-workings, and is not seen at the surface.

The *Boulmer Dyke*, which, according to Tate, is only seen on the coast, is 100 feet wide.

The *Hampeth Dyke*, 150 feet wide, is seen in Hampeth Burn, South-West of Shilbottle.

The *Howick Dyke*, belonging to this series, is interesting because of its nearness to the Whin Sill, with which, however, it cannot be actually connected. It is only seen on the coast.

The *Cornhill Dyke*, cutting for 7 miles through Tuedian and Bernician beds, from half a mile below Coldstream to Milkington, Heaton Mill, and Mattalees, seems to belong to these dykes.

Many of the dykes above described have altered and baked the deposits through which they cut, but their effects are by no means constant, coal being sometimes completely coked, and sometimes but very slightly—if at all—affected by contact with them. This irregular action is strikingly illustrated by the Cockfield Dyke, as has been recently shown by Mr. Hugh Bramwell in an interesting paper read before the Durham College of Science Geological Club.* Most of the dykes in the coal-field are remarkable for the coking which they have produced—as, for instance, the Hebburn Dyke.

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* Read on 10th April, 1886.

CHAPTER XII.

IGNEOUS ROCKS (CONTINUED)—THE GREAT WHIN SILL.

THIS is the name given to a sheet of Basalt (Diabase of Continental authors), the outcrop of which stretches across Northumberland from Greenhead to a few miles South of Berwick, is exposed as a huge inlier in Upper Teesdale, and probably underlies almost the whole of the Southern and Eastern portions of Northumberland. Of undoubted igneous origin, this flow of Basalt has yet given rise to much contention among geologists, some arguing that it was a regularly interbedded Trap, the mineralogical character of which alone distinguished it from the beds above and below, and others, with—as it has since been proved—more reason, that it was a purely intrusive mass, injected, just as the ordinary dykes are, long after the deposition of the rocks amongst which it lies.

The evidence relied on by the former party was, chiefly, that in the mining district of Alston Moor and the South Tyne, the Whin Sill did appear to lie regularly at one horizon. That on the other side—which seems to be perfectly unassailable—being found in the altered, or metamorphosed, character of the rocks *above* the Whin Sill, especially when they consist of shales, and in the fact that the Whin does not lie at one uniform level amongst the sedimentary strata, but frequently comes up in bosses, cutting through the rocks, and shifts its relative position amongst them to the extent of 1,000 feet or more in short distances.*

The importance attached to a settlement of this question of the intrusion of the Whin Sill is due, to some extent, to the fact that the late Professor Phillips relied upon that basaltic sheet as a boundary between his two great divisions of the Carboniferous Limestone series—the Yoredale Rocks and the Scaur Limestones. As it is now shown that it shifts its position, being sometimes found below, but more often above, the supposed base-line of the Yoredale Beds, its value as a line of boundary is entirely lost.*

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* See Topley and Lebour "On the Whin Sill in Northumberland."—*British Association Report for* 1873, Part II., p. 92.

The Whin Sill is wholly comprised within the Bernician series in Northumberland, and chiefly within its upper portion.

On entering Northumberland near Greenhead the Whin is, for a space, found lying close to the "Great Limestone" some 700 or 800 feet above its Alston horizon, but returns to its more usual position before long, about which, with fluctuations above and below within about 300 feet, it keeps for many miles, crossing the North Tyne, near to which river it assumes the North-Easterly trend followed by all the beds of the district. The Roman Wall runs for many miles along the crest of the Whin Sill escarpment. Here, and at Shepherd's Gap, an easily observable change of horizon takes place. (See Fig. 4.) At Low Teppermoor it is seen at about its lowest position in this portion of its course; and here also a surface break (of which there are several along the crop of the sheet) is very well shown. Thence it continues by Gunnerton (see Fig. 5) to the North-East, pretty much along the same horizon, till it reaches Swinburne Mill, where another break occurs, accompanied by a rise of a few fathoms to the next higher bed of limestone. From this point the Whin Sill runs almost due North, in a fine line of semi-columnar crags, as far as Knowes Gate, where it crosses the Wansbeck Valley Railway. In this distance it is twice interrupted by surface breaks unattended with change of horizon—at Sweethope and the Berry Hills. A little to the North of the line this long basaltic range terminates abruptly, re-appearing at intervals through a drift-covered country. Parallel to this great ridge, however, and not quite a mile to the East of it (three beds of limestone, with their associated sandstones and shales, intervening), is

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* Lebour "On the Limits of the Yoredale Series in the North of England."—*Geological Magazine*, Decade II., Vol. II. (1875), p. 539.

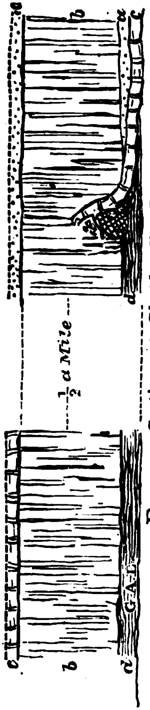


FIG. 4.—*Section at Shepherd's Gap.*

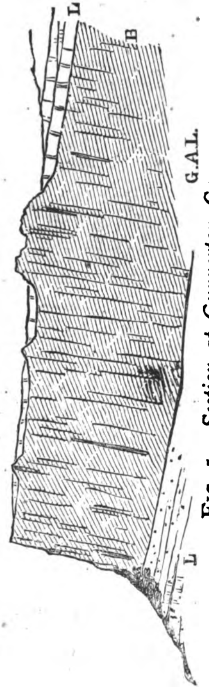


FIG. 5.—*Section at Gunnerton Crag.*

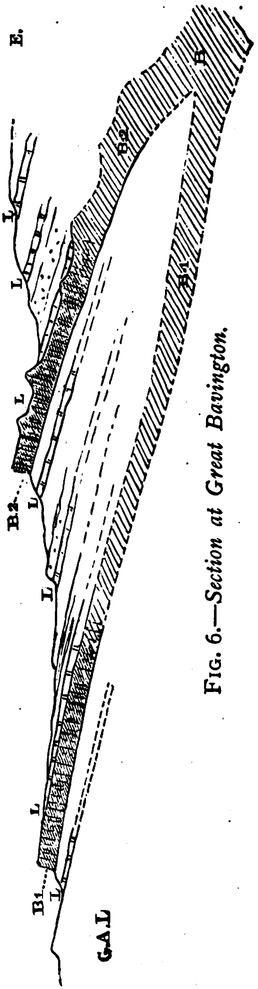


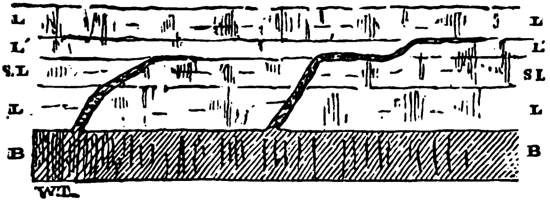
FIG. 6.—*Section at Great Bavington.*

another equally thick (and in places even thicker) but much more regular sheet of Basalt, which may be looked upon as a branch of the Whin Sill, and which runs from Homilton, near Bavington (see Fig. 6), to Elf Hills, to the North-East of Kirk-Whelpington. This Eastern sheet is much more subject to breaks than the main or Westerly one, and towards its Northern extremity comes to the surface, usually not as a continuous bed, but in bosses or isolated masses of greater or lesser size.

About half a mile to the North of the village of Chollerton there is a patch of basalt quarried in a small plantation by the roadside, which is probably a separate boss belonging to the branch of the Whin Sill just mentioned. This is rendered more probable by the fact that a thin sheet of basalt (rather light-coloured and very fine-grained) is seen in the bed of the North Tyne a little below Haughton Castle. This thin bed may be the Southernmost exposure of the Eastern Whin Sill.

At Elf-Hills Quarry, where the Four-Fathom Limestone was until lately wrought, the whin overlies and breaks through the limestone; but a more interesting case of intrusion was observed here by Sir Walter C. Trevelyan a few years back, when a thin layer of fine-grained whin underlying the limestone was seen sending up strings of trap through the overlying limestone beds. (See Fig. 7.) At the extremity of these shoots of whinstone a singular black earthy substance was noticed, the like of which has since been detected by Mr. David Burns, F.G.S., elsewhere at the point of junction

FIG. 7.—*Section at Elf-Hills Quarry.*



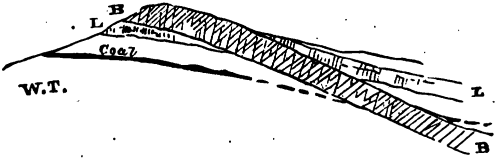
between whin and limestone.* On partially analysing a portion of this stuff, Mr. J. T. Dunn, M.Sc., ascertained that it contained as much as 17 per cent. of combustible and volatile matter—probably free carbon. This, taken in conjunction with the fact that the Whin Sill in its irruption undoubtedly absorbed portions of the beds through which it poured, tends to confirm certain theories advocated by Mr. Burns in the paper referred to. At Elf-Hills, too, pieces of shale some feet in length may be seen caught up and enclosed in the basalt.

To the North of Elf-Hills there is a broad flat tract of drift-covered land, beyond which the whin is again seen (at Hartington and Gallow Hill) lying in the same position—*i.e.*, between the Great and Four-Fathom Limestones. Again, there is a broad drift-covered valley, beyond which the whin is seen at Dyke-Head. It here seems to come up as a great boss, and lies lower in the series. A bore-hole put down on the South side of Greenleighton Farm found the whin just below the Six-Yard Limestone.†

In Fallowlees Burn the whin lies about 100 feet below the position last mentioned. From this place it can be traced for about a mile to the North, apparently keeping at the same horizon.

At Ward's Hill, near Forest Burn, the whin cuts through the Great Limestone. (See Fig. 8.) It is not seen again until about four or five miles South of Alnwick. Thence it can be traced Northwards, past Rugley nearly to Alnwick, lying about 100

FIG. 8.—*Section at Ward's Hill.*



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[*] D. Burns "On the Intrusion of the Whin Sill."—*Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. XXVII. (1878).

[†] This is the Three-Yard Limestone of Teesdale.

feet or rather more above the Hobberlaw Limestone, which is the lowest good and thick limestone in the district. Here, too, the whin has its lowest known position, as it lies nearly 1,000 feet below the Great Limestone. The beds immediately above the whin are seen in a stream South-East of St. Margaret's Farm, where they are much altered.*

From this point the course of the Whin Sill has been well described by the late Messrs. W. Hutton and G. Tate, and by Mr. E. F. Boyd, F.G.S.†

From Ratcheugh, Northwards to Dunstanburgh, the whin lies in beds and bosses at various horizons. At the former place it is below the Eight-Yard Limestone, and the whin occurs in three separate sheets or flows, separated from each other by altered shale and limestone. About Howick many cases of enclosed masses of sandstones and other rocks are observable. At Peppermoor—according to Mr. Tate—there are indications of two intrusions. At Dunstanburgh the basalt forms the fine sea cliff surmounted by the ruined castle, and overlies the Great Limestone. Thence, by Spittleford and Embleton—at or about the same horizon—to St. Mary's Haven and Old Newton. Between Newton North Farm, on the South side of Beadnell Bay, and the Farne Islands, the Whin Sill is nowhere to be seen. The islands are, however, entirely formed of it, except where some considerable patches of altered shales, limestones, and sandstone occur, enveloped in the trap. Similar cases of enclosed sedimentary rocks are well seen on the coast just North of Bamburgh Castle, which, like Dunstanburgh, stands on a cliff of Whin Sill columns.‡

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* Most of the above description is taken from Topley and Lebour's paper "On the Intrusive Character of the Whin Sill in Northumberland," read before the Geological Society of London on December the 6th, 1876, and published in the *Quarterly Journal* of the Society, Vol. XXXIII. (1877), p. 406.

† W. Hutton in *Transactions of the Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne*, Vol. II. (1832). p. 187. G. Tate in *Proceedings of the Berwickshire Naturalists' Club*, Vol. VI., p. 197. E. F. Boyd in *Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. IX. (1861), p. 185.

‡ See Sir W. C. Trevelyan, *Memoirs of the Wernerian Society*, Vol. IV. (1823), p. 253; and Lebour and Fryar "On the Harkess Rocks, near Bamburgh."—*Transactions of the North of England Institute of Mining and Mechanical Engineers*; Vol. XXVI. (1877).

Indeed, the low-lying but beautifully-exposed Harkess Rocks, which lie partly between tide-marks from Bamburgh to Budle, display almost every vagary to which igneous rocks are subject. Enclosed beds of shale—as in Figs. 9 and 10—or of limestone—as in Figs. 11 and 12—are common. The division of the

Sections of Enclosed Rocks (Harkess Rocks).

FIG. 9.

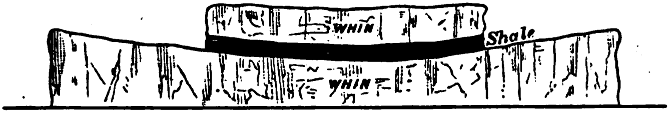


FIG. 10.

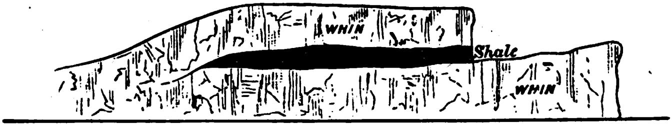


FIG. 11.

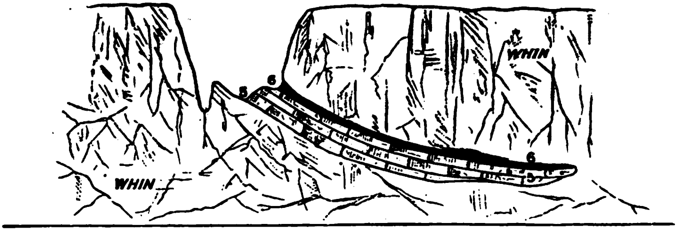
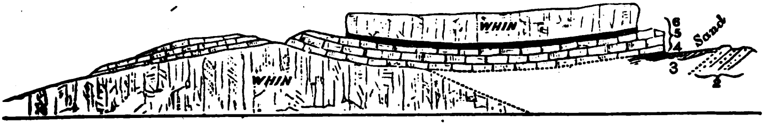


FIG. 12.



whin into separate sheets is obvious. The upper layers of each flow are very vesicular (as is also the case at Dunstanburgh and elsewhere), and in places amygdaloidal, whilst the pitch-like or rope-like crumplings of their surfaces are in every way similar to those seen in modern volcanic rocks. Some of these appearances are such as have been usually regarded as peculiar to rocks which have been erupted on the surface or at the bottom of the sea. That they are not so restricted is abundantly proved here. The general transgressive character of the basalt is well shown in Figs. 13, 14, and 15.

FIG. 13.—*Section along the Stag Rock (Harkess Rocks).*

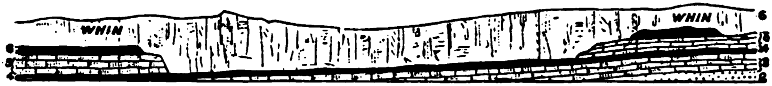


FIG. 14.—*Section across the same.*

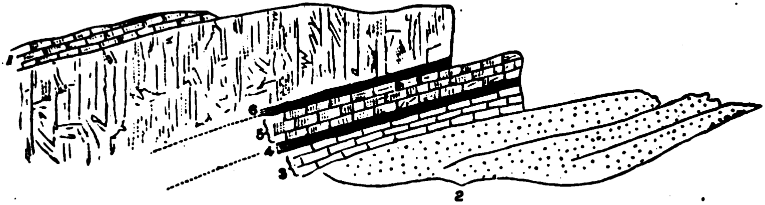
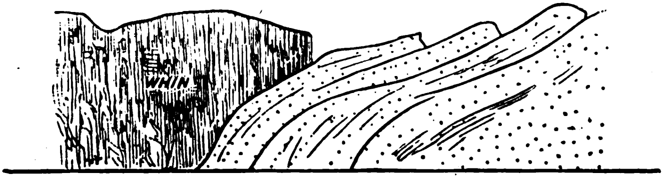


FIG. 15.—*Section by the Target (Harkess Rocks).*



Near Stanhope, in Weardale. is a thin sheet of basalt, which for some miles is seen to be interbedded in one of the Bernician Limestones. This is sometimes called the Little Whin

Sill, and was first described by the late Sir Walter Trevelyan, Bart., F.G.S. It is very similar to the thin sheet which occurs in the North Tyne, close to Haughton Castle. In both cases the position of the basalt is considerably above that of the Great Whin.

The Whin Sill here covers a large extent of country, and is very well seen from the sea coast inland towards Belford, the celebrated Spindlestone Crags belonging to it. Thence, with important breaks partly due to large faults, the basaltic range runs to the Kyloe Crags by Middleton and Knucton.

In Durham, where that county marches with Yorkshire, the Great Whin is exposed by denudation many miles to the East of its proper outcrop along the Penine Escarpment at High Cup (or High *Cope*) Nick, and elsewhere. In this inlier, however, it is seen to great advantage, and forms the beautiful waterfall of the High Force, and, higher up, the still grander and wilder Caldron Snout. The alteration of the limestone adjoining the basalt at the High Force into saccharoidal marble has long been part of the stock-in-trade of geological text-book writers.

Throughout this long serpentine course the Great Whin Sill, although it shifts its horizon continually, yet follows in a general way the strike of the sedimentary beds, so that, before the geology of the country was worked out in any detail, there certainly was a *primâ facie* likelihood of its being a truly interbedded sheet. Its thickness varies very greatly, being scarcely 20 feet in places and 150 feet in others. On an average it is from about 80 to 100 feet thick.

That the Whin Sill has been injected between the strata after their deposition and consolidation is now sufficiently evident.

"The exact geological date at which the intrusion took place cannot be determined. Northumberland offers no conclusive evidence on the subject; but, so far as the evidence in this and other districts goes, it seems probable that the intrusion took place at the close of the Carboniferous period."*

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* Topley and Lebour, *loc. cit.*, p. 421

Speaking lithologically, the Whin Sill is thus described by Mr. S. Allport, F.G.S.:—"A specimen of it from Ward's Hill, near Rothbury, is a well-crystallized greyish-black basalt, containing the usual constituents; the Plagioclase is distinctly striated, the Augite occurs here and there in twin crystals, and there are a few serpentinous pseudomorphs of Olivine. Grains of Magnetite are thickly scattered through it. A dolerite from Elf-Hills, in Northumberland, is not so well crystallised as the preceding, and is more altered; the Augite is partially converted into a grey substance, there is some disseminated Chlorite, and an altered glass fills the spaces between the constituents."*

Mr. Teall, who has devoted much time to the petrological examination of the Whin Sill, has never found it containing any Olivine. He regards it as a plagioclase-augite rock very similar to that of the dykes, and irregularly like "the plagioclase-augite rocks which bulk so largely in the Triassic strata of the New England States, near the Eastern coast of North America."

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† *Quarterly Journal* of the Geological Society, Vol. XXX. (1874), p. 552.

CHAPTER XIII

IGNEOUS ROCKS (CONTINUED)—THE CHEVIOTS, ETC.

THE Cheviots proper are as well defined geologically as they are topographically. No contrast can well be greater than that presented by the high green rounded contours of this "massif" and the rugged craggy heather-clad outlines of the Carboniferous rocks which skirt along their base. Nowhere can this be better seen than from some of the crags of the Harbottle Grits in Upper Coquetdale—from the Drake Stone, for instance. Strikingly homogeneous are the features of the Cheviots—the deep valleys of the range, its steep slopes, its moss-hag covered sub-conical tops—all are alike from Wooler to Clennell. To the geologist's eye the igneous origin of these hills is evident at a distance; and igneous the entire mass undoubtedly is, but various are the kinds of igneous rocks of which that mass is composed. The area covered by these rocks in Northumberland is about 200 square miles, and, difficult of access as the region is, it is not to be wondered at if our knowledge of its geological structure be still scanty as to details. Mr. Teall has already thrown a flood of light upon the nature of the chief petrological "species" found there, and from Mr. Clough, of H.M. Geological Survey, a similarly luminous exposition of the relations of these rocks to one another is daily expected, but has, unfortunately, not yet been published.

1. *Granitic Rocks*, only occasionally present, but well shown in places, as in the hills below "Cheviot" itself, about the head of the Breamish, and at Hedgehope. Much of these rocks is syenitic looking, but no hornblende has hitherto been discovered in them. The rest is grey. These granites contain not only the orthodox felspar (orthoclase and oligoclase),

mica, and quartz, but also colourless augite, This unusual fact was first pointed out by Mr. Teall, who writes as follows on the subject:—"The granites of the Cheviots may therefore be termed augite-biotite granites. The occurrence of quartz and orthoclase in association with augite is an interesting and somewhat important fact. The only other British localities in which I have observed a similar association are Carrock Fell in Cumberland, Groby and some other places in Charnwood Forest, and the Isle of Mull. In all these cases the augite is associated with micropegmatite. . . . . Rocks closely allied to the Cheviot augite-granites occur at Laveline and Oberbrück in the Vosges."*

2. *Quartz-Felsites.*—These rocks occur as dykes cutting through the andesites and porphyrites. They consist usually, according to Teall, of a micro-crystalline ground mass, in which are embedded porphyritic crystals of orthoclase, plagioclase, quartz, and biotite.† These dykes appear to become much more numerous on the Scottish side of the Border.

3. *Andesites and Porphyrites.*—These form by far the larger portion of the Cheviots. They are the lavas of the district. There is a gradual passage between the andesites—which are the unaltered, and the porphyrites, which are the partly altered lavas. Petrologically these rocks are of great interest, since, notwithstanding their great antiquity, they agree in all essential points with lavas of Tertiary and recent origin. Mr. Teall describes several varieties, which it will be sufficient to enumerate here merely, viz., Pitchstone Porphyry (now rejoicing in the name hypersthene-augite-andesite‡), Hypersthene-Porphyrite, Hypersthene-Augite-Porphyrite, Augite-Porphyrite, and Mica-Porphyrite.

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* "Petrographical Notes on some of the Igneous Rocks of Northumberland," separately issued by the Geologists' Association, July, 1886, p. 29.

† *Op. jam cit.*, p. 28.

‡ See Dr. Petersen, "Mikroskopische und Chemische Untersuchungen am Enstatit-porphyrit aus den Cheviot Hills."—Inaugural Dissertation, Kiel, 1884.

The red varieties of porphyrite are abundant. They are well shown at Biddlestone, a little to the East of the Hall, where the stone is quarried, and where the joint-faces are marked with beautiful dendritic markings. Brownish to blackish rocks belonging to this group are also common.

4. *Tuffs, etc.*—Under this head may be grouped all those fragmental rocks found associated with the ancient Cheviot lavas (andesites and porphyrites). These have often been referred to by the conveniently vague term ash. Some of hem may probably be correctly so termed, but others are certainly not ashes according to any true meaning of the word. Most of these rocks are of loose and porous texture, and consist more or less of fragments of altered igneous material of rough and angular shape. There are, in fact, agglomerates of various kinds. Many of them are much filled with infiltrations of chalcedony and other minerals, and their original structure and composition are thus still further obscured. One kind of rock, however, which is, I find, now spoken of as an ash, appears to me to be very different from the rest. This is a beautiful hard red quartz breccia, which crops out chiefly in the neighbourhood of Ingram, and which merits closer study than it has yet received. A fine block of it, with a polished face, is to be seen in Ingram Churchyard, where it serves as a memorial to the late Mrs. Allgood and her children, victims of the disastrous Abbots Ripton railway collision of a few years back. The rock is also visible *in sitû* in the bed of the burn close by.

The above are the four chief constituent groups of the Cheviot Traps, but it must be understood that much more knowledge is wanted before the large tract of country which they occupy can be said to be at all satisfactorily known.

In many parts of the Cheviots there is a marked bedded appearance in some of these igneous rocks. At certain places this appearance of bedding and regular dip is so distinct as to lead one to doubt whether the rocks be not highly metamorphic and not truly igneous. Apparent dips of this kind can sometimes be traced consistently for miles, but at the same time it must be admitted that more often the self-same rocks are wholly devoid of bedding-like planes, and of anything approaching to uniform dip. The pseudo-dip and bedding can be seen to perfection on the banks of the Ridlees Burn, where a most interesting section, to be presently described, is to be seen.

The age of the Cheviot rocks is not the same for the various members of the group. It seems highly probable, for instance, that some of the andesites are of later age than the porphyrites; and I would here throw out the suggestion that the detached minor bosses of trap seen piercing through the lowest Carboniferous rocks near the summit of the Carter Fell road are to be assigned to this era in the history of these eruptive rocks. Then the quartz-felsite dykes are newer than the earlier lavas, though probably contemporaneous with the later ones. How far the granites may be separated in age from the andesites and porphyrites I am not in a position to say. Mr. Teall regards it as possible that they may be merely the plutonic representatives of the volcanic rocks, and that they constitute, in fact, a portion of the core of the Old Red Sandstone Cheviot volcano. There would probably be at least three periods of intrusion represented in the Cheviot mass. An early one (that of the older porphyrites, etc.), posterior to the Makendon Silurian rocks, but prior to the Basement beds of the Carboniferous; a second one (that of the newer volcanic rocks), in Carboniferous times probably; and a third (*e.g.*, the Acklington Dyke), which was contemporaneous with that of the East and West Whin Dykes. These conclusions are based on the following facts:—

1. The Silurian beds at Makendon are, wherever they are seen in contact with the Cheviot rocks, tilted up or overlain by the latter (see Plate II., fig. 1.)

2. The lowest Carboniferous rocks are, where no faults are present, as at Cottonshope Head and the Ridlees, seen to rest on the Cheviot rocks and are perfectly undisturbed by them (see Plate IV., fig. 3).

3. Isolated patches of Lower Carboniferous Sandstone and of Basement beds are found lying undisturbed on the flanks of the Cheviot, as by the "Clennell Street" above Alwynton and on Whitelaw, East of Yevering (see Plate IV., fig. 2).

4. The Basement beds, like the higher Tuedian beds to a certain extent, are made up of pebbles of Cheviot Porphyrite.

5. Some of the Andesites appear to pierce through the porphyrites, although they do not always have that appearance.

6. These andesites are sometimes—as up Puncherton Burn (running into the Alwyn)—seen to pass into a brecciated conglomerate in which blocks of rock, apparently of Lower Carboniferous origin, besides others of earlier age, and mixed with fragments of porphyrite, are embedded in an ashy matrix.

7. The bosses of trap seen below Whitelee, by the Carter Fell road, are quite unlike either the dykes and bosses which are common in the rest of the region, while they seem to be very similar to some of the darker Cheviot volcanic rocks in the neighbourhood of which they are found.

In "Good Words" for 1876 there is a series of articles by Dr. James Geikie, F.R.S., on the Cheviot Hills. The chief geological conclusions arrived at are thus abstracted:—*

"Describes the scenery and extent of the region. The Scottish side is the most abrupt. The age of the igneous rocks, forming the greater part of the range, is intermediate between that of the greywacke beds and of the red and white sandstone (Upper Old Red Conglomerate or Lowest Carboniferous), lying unconformably upon the former. These igneous rocks consist chiefly of porphyrites. At Hindhope the oldest of them (the Ash Beds) are to be seen. The early volcanic outbursts were submarine, but those at the close of the period of activity were subaërial. In early Carboniferous times there followed another volcanic period, to which the plugged-up vents of Rubers Law, Black Law, etc., belong. Describes the glacial deposits fully. The Cheviots were covered by the ice-sheet when at its thickest, but they divided the flow between Scotland and England."

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* See *Geological Record* for 1876 (1878), p. 12.

The fourth group of igneous rocks mentioned at p. 64 as occurring in the district is a mass of felsitic rocks which only just enters North Northumberland at Carham, and forms part of the eruptive mass which, in Scotland, occupies a distinct position in the Calciferous Sandstone series (= Tuedian). Lastly, mention must be made of some dykes of mica-trap (minette) found in the Teesdale inlier of Silurian shales near the High Force, and which are the counterpart of the minette dykes in the Silurian rocks of Westmoreland.

CHAPTER XIV.

MATERIALS FOR A PALÆONTOLOGY OF NORTHUMBERLAND.

FOR the Permian fossils the student is referred to Mr. R. Howse's publications in the *Transactions of the Tyneside Naturalists' Field Club*,* and to Professor King's Monograph in the volumes of the Palæontographical Society. Practically it is now all but impossible to obtain any in Northumberland except those of the marl-slate, at Cullercoats, during the very lowest tides. In Durham, however, collecting in rocks of this age is still possible. The classical localities of Humbledon Hill and Tunstall Hill are still open, and from time to time yield many specimens, among which *Productus horridus* and fine masses of Fenestellid Polyzoa are conspicuous. Mr. Kirkby's beautiful collection of Permian fossils is now to be seen in the Natural History Society's Museum at Newcastle, where, together with Mr. Howse's types and other specimens, the local Permian fauna is quite exceptionally well illustrated. A large series of fossils from the neighbouring Magnesian Limestone localities is also to be found in the Sunderland Museum. This is due chiefly, I understand, to the industry of Mr. Cameron, and, when fully named and arranged, will be of great value. Some of the smaller forms occur in abundance at Seaham Harbour. The late Mr. Joseph Duff, of Bishop Auckland, was one of the most successful collectors in the Durham marl-slate. Many of his most remarkable finds are now in the Newcastle Museum, and are types described, most of them, in the *Transactions of the Tyneside Field Club and Natural History Society* by Messrs. Albany Hancock and R. Howse. It must be remembered that fishes, though most numerous in the marl-slate, have from time been found also in the main mass of the Magnesian Limestone above.

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* 1848 and 1852. Also separately printed.

For the Coal-Measure fossils he is referred to a "Synopsis of Organic Remains found in the Northumberland Coal-Measures," also by Mr. Howse, published at p. 59 of the "Industrial Resources of the Tyne, Wear, and Tees" (second edition, 1864), and for the plants to Lindley and Hutton's "Fossil Flora," the "Illustrations of Fossil Plants,"* and the "Catalogue of the Hutton Collection of Fossil Plants." The figured specimens in the Hutton Collection are preserved in the Newcastle Museum, together with many others of equal local interest. Most of the non-figured examples belonging to this collection are in the hands of the Durham College of Science.

Insect remains were some years ago found in the uppermost known Coal-Measures on the banks of the Wear opposite Claxheugh, above Sunderland. Mr. Kirkby, who made this discovery, at the same time found a very problematical organism, to which he gave the name *Ancylus Vintii*. This reference, however, seems very doubtful.

Of late years *Spirorbis* has been found in large numbers at a great many horizons in the coal-field, and in a less degree this is also true of *Lingula*. The Walker and Gosforth colliery heaps are good localities.

The Gannister beds were thought to be unfossiliferous in Northumberland and Durham until 1878, when I had the good fortune to discover some in the rocks of that age at Apperley, near Whittonstall, to the South of Stocksfield Station. The list is at present a small one, viz.:—

Aviculopecten papyraceus.
Av., sp.
Orthoceras, sp.
Encrinite stems.

The most interesting fossil-bearing series in the two counties is, however, without exception, the Bernician, where every limestone, many of the shales, and some of the sandstones, yield their quota of fossils. A full list of all the species that have been found would be out of place here, even were it not *ultra vires*, but the following detached lists will, I trust, give a sufficient idea of the richness of this fauna. In the quoted lists the nomenclature of each author has been retained.

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* This work, and the "Catalogue" next mentioned, were published by the North of England Institute of Mining and Mechanical Engineers in 1877 and 1878 respectively.

First will be given lists of the fossils known to occur in the highest or Felltop Limestone:—

FELLTOP LIMESTONE, at Harlow Hill.

Lithostrotion junceum, Flem.
L. irregulare, Phill.
L. Portlocki, Bronn, very plentiful.
Cyathophyllum, sp.
Griffithides, sp.
Poteriocrinus, two sp, (?)
Orthisina (Streptorhyncus) crenistria, Phill.
Productus giganteus, Mart.
Pr. latissimus, Sow.
Pr. semireticulatus, Mart.
Pr. costatus, Sow.
Pr. punctatus, Mart.
Pr. longispinus, Sow.
Euomphalus, a large species.
Pinna flabelliformis, Mart.
Chomatodus cinctus, Ag.
Petalodus acuminatus, Ag.

Besides several undetermined forms.

FELLTOP LIMESTONE HORIZON; a calcareous shale at Foxton Hall, near Alnmouth.

Clisiophyllum bipartitum, McCoy.
Cl. sp., a long vermiform species.
Chœtetes tumidus, Phill.
Griffithides, sp.
Gr. Farnensis, Tate.
Poteriocrinus nuciformis, McCoy, perfect calyces not uncommon.

Crinoidal plates of large size.
Crinoidal stems, some exceedingly large, always found in little clusters like the small belemnites in the Lower Lias.
Fenestella plebeia, McCoy.
F. membranacea, Phill.
Glauconome pluma, Phill.
Gl., sp.
Lingula squamiformis, Phill., in small ironstone nodules.
Productus punctatus, Mart.
Pr. longispinus, Sow.
Pr. giganteus, Mart. sp.
Pr. latissimus, Sow., very common. Small specimens.
Pr. semireticulatus, Mart.
Orthis Michelini, Lév.
Edmondia arcuata ?
Macrocheilus, sp.
Murchisonia, sp.
Bellerophon Urei, Flem.
Euomphalus, sp.
Orthoceras attenuatum, Flem.
Fish remains—not yet determined. *

The list which follows is specially interesting, as it represents the results of many years' collecting in one set of beds by a good collector living on the spot. The species enumerated were all found by the Rev. E. Jenkinson in the Lowick quarries, which are all in the Upper Bernician Series (=Yoredales), ranging from the Great Limestone at Dryburn to the fifth bed of Limestone below it. It is unfortunately impossible now to refer each species to its particular bed, but the whole forms an excellent example of the Upper Bernician fauna at one locality in North Northumberland. The specimens are now in the Woodwardian Museum at Cambridge.

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* See Lebour on "Fossils found at Foxton Hall."—*Berwickshire Naturalists' Club Proceedings for* 1880, p. 79.

List of Fossils from the Lowick beds (Northumberland), from Sedgwick and McCoy's "British Palæozoic Fossils":—

Discina bulla, McCoy, from red sandy bed. Unique specimen.
D. nitida, Phill. sp., (=*Orbicula nitida*, Phill.), dark limestone.
Seminula virgoides, McCoy, rare.
Spirifera duplicicosta, Phill., rare.
Sp. ovalis, Phill. var. *hemispherica*, not uncommon.
Sp. trigonalis, var. a, *trigonalis*, Mart. sp., common.
Sp. tr., var. b, *bisulcata*, Sow., rare.
Sp. (Martinia) lineata, Mart. sp., very common.
Sp. (Martinia) symmetrica, Phill., very common.
Athyris ambigua, McCoy, common, of small size.
A. gregaria, McCoy, var. a, *trapezoidalis*, McCoy, rare.
A. paradoxa, McCoy, common.
Hemithyris acuminata, Mart., sp., var. *pugnus*, Sow., common.
H. pleurodon, Phill., rare.
Camerophoria laticliva, McCoy.
Orthis connivens, Phill., sp., rare.
O. resupinata, Mart. sp., very rare.
Leptæna (Strophomena) cylindrica, McCoy, common.
L. (Chonetes) polita, McCoy, rare.
Producta aculeata, Mart., sp., not uncommon.
Pr. corrugata, McCoy, rare.
Pr. costata, Sow., rare.
Pr. elegans, McCoy, not uncommon.
Pr. fimbriata, Sow., abundant.
Pr. Flemingii, Sow., common.
Pr. gigantea, Mart., sp., very abundant.
Pr. punctata, Mart., sp., not uncommon.
Pr. scabricula, Mart., sp., not uncommon.
Pr. striata, Fisch., sp., rare.
Producta tortilis, McCoy, not very uncommon.
Pecten (?) fimbriatus, Phill., common.
P. subelongatus, McCoy, not rare.
Amusium deornatum, Phill., sp., rare.

A. Sowerbyi, McCoy.
Pterinea lævigata, McCoy, two young (?) specimens.
Pteronites persulcatus, McCoy.
Streblopteria lævigata, McCoy; rare, of large size.
Str. pulchella, McCoy, rare.
Aviculopecten cœlatus, McCoy, rare.
A. cancellatus, McCoy, rare.
A. concavus, McCoy, not uncommon.
A. conoideus, McCoy, one specimen.
A. docens, McCoy, common.
A. granosus, Sow., sp.
A. Ruthveni, McCoy, one small specimen.
A. segregatus, McCoy, rare.
Lithodomus Jenkinsoni, McCoy, not uncommon.
Anodontopsis (?) pristina, M. V. K., sp., rare.
Myophoria depressa, Portl., sp., common.
My. obliqua, McCoy, common.
Pinna flexicostata, McCoy, very common.
P. spatula, McCoy, rare.
Edmondia Egertoni, McCoy, not very common.
E. Josepha, de Kon., rare.
E. oblonga, McCoy, abundant.
E. phaseolina, Gold., sp., not uncommon.
E. rudis, McCoy, rare.
E. scalaris, McCoy, very rare.
E. sulcata, Phill., sp., extremely abundant.
E. unioniformis, Phill., sp., rare.
Sanguinolites iridinoides, McCoy, very abundant.
S. striato-lamellosus, de Kon., sp., rare.
S. subcarinatus, McCoy.
S. sulcatus, Flem., sp., common.
S. tricostatus, Portl., sp., very rare.
S. variabilis, McCoy, not uncommon.
Leptodomus costellatus, McCoy, common, in shales.
Conocardium aliforme, Sow., sp.
Solenomya primæva, Phill., very common.
S. pr., var. b, *Puzosana* de Kon., not uncommon.
Conularia quadrisulcata, Miller MS., one small specimen.

Pleurotomaria altavittata, McCoy, not uncommon.
Pl. decipiens, McCoy, rare (two varieties).
Pl. erosa, McCoy, rare.
Pl. Griffithi, McCoy, very rare.
Murchisonia dispar, McCoy, not very uncommon.
Polytremaria catenata, de Kon., sp., rare.
Platyschisma glabrata, Phill., sp., very small specimen.
Pl. helicoides, Sow, sp., common.
Straparollus (?) catillus, Mart., sp., rare.
Str. costellatus, McCoy, rare.
Str. Dyonysii, McCoy, rare.
Str. pentangulatus, Sow., sp., internal casts.
Str. tabulatus, Phill., sp., not uncommon.
Naticopsis variata, Phill., sp., two specimens.
Loxonema rugifera, Phill., very rare.
Macrocheilus acutus, Phill., common.
M. brevispiratus, McCoy, rare.
M. limnæiformis, McCoy, not very common.
M. sigmilineus, Phill., sp., rare.
M. (?) spiratus, McCoy, common.
Dentalium dentaloideum, Phill., sp., very common.
Bellerophon decussatus (?), Flem., very large specimens, not very rare.
B. Dumonti, d'Orb., casts (?).
B. Larcomi, Portl., one specimen.
B. Phillipsi, McCoy, rare, casts.
B. recticostatus, Portl., one cast.
Nautilus bilobatus, Sow., rare.
N. coronatus, McCoy, very rare.
N. costato-coronatus, McCoy, very rare.
N. globatus, Sow., not very uncommon.
N. ingens, Mart., sp., common, of large size.
N. oxystomus, Phill., rare.
N. quadratus, Flem., common.
Aganides reticulatus, Phill., sp., one obscure fragment.
Orthoceras Breyni, Mart., sp., not uncommon.
O. cordiforme, Sow., rare.
O. cornu-vaccinum, McCoy, not very uncommon.

O. cylindraceum, Flem., rare.
O. Flemingii, McCoy, very rare.
O. fusiforme, Sow., not very common.
O. giganteum, Sow., very common and of great size.
O. inequiseptum, Phill., rare.
O. laterale, Phill., not uncommon.
O. rugosum, Flem., rare.
O. Sowerbyi, McCoy, not uncommon.
O. undatum, Flem., not very uncommon.
Diphyphyllum gracile, McCoy, not uncommon.
Clisiophyllum prolapsum, McCoy, var. and *minor*, one specimen.
Siphonodendron sexdecimale, Phill., sp., not uncommon.
Cladodus striatus, Ag., rare.
Cochliodus magnus, Ag., common (?).
C. striatus, Ag., very rare.
Helodus planus, Ag., rare.
Leptacanthus Jenkinsoni, McCoy, not very uncommon.
Petalodus acuminatus, Ag., not uncommon.
P. Hastingsii, Owen, very rare.
P. rectus, Ag., not uncommon.
Pœcilodus Jonesii, Ag., very rare.
Psammodus cornutus, Ag., rare.
Ps. rugosus, Ag., rare (var. *porosus*).

Next is a list of the fossils found in two of the beds included in the Lowick series, but not restricted to that locality, the occurrence in each bed being here discriminated, however.

N.B.—The Foraminifera will be given separately.

List of fossils found in the "Great" and "Fonr-fathom" Limestones:—

	Great Limestone.	Four-Fathom Limestone.
Chætetes tumidus, Phill.	*	*
Aulophyllum fungites, Flem.	*	*
Cladochonus bacillaris, McCoy	–	*
Favosites parasatica, Phill.	*	–
Lithostrotion irregulare, Phill	*	–

	Great Limestone.	Four-Fathom Limestone.
Griffithides Farnensis, Tate	*	*
Gr., sp.	–	*
Leperditia, sp.	*	–
Spirorbis carbonarius, Murch.	*	–
Serpulites carbonarius, Salter	–	*
Archæocidaris Urei, Flem.	*	*
Poteriocrinus crassus, Mill.	–	*
Hydreionocrinus globularis, de Kon.	–	*
Glauconome pulcherrima, McCoy	*	*
Gl. pluma, Phill.	*	–
Fenestella plebeia, McCoy	*	–
F. membranacea, Phill.	*	–
Lingula mytiloides, Sow.	–	*
L. squamiformis, Phill.	*	*
L., sp.	–	*
Productus fimbriatus, Sow.	*	*
P. punctatus, Mart.	*	*
P. scabriculus, Mart.	*	–
P. Flemingii, Sow.	*	*
P. Martini, Sow.	*	*
P. semireticulatus, Mart.	*	*
P. Cora, d'Orb.	*	*
P. latissimus, Sow.	*	*
P. giganteus, Mart.	*	*
Orthis Michelini, Lev.	*	*
O. resupinata, Mart.	*	*
Streptorhyncus crenistria, Phill.	*	*
Str. arachnoidea, Phill.	*	–
Rhynchonella pleurodon (?), Phill.	*	*
Spiriferina laminosa, McCoy	*	–
S. octoplicata, Sow.	*	–
Spirifer pinguis, Sow.	–	*
S. lineatus, Mart.	*	*
S. Urei, Flem.	*	–
S. glaber, Mart.	*	*
S. sex-radialis, Phill.	*	–
S. bisulcatus, Sow.	*	*

	Great Limestone.	Four-Fathom Limeetone.
S. trigonalis, Mart.	*	*
Athyris ambigua, Sow.	–	*
A. plano-sulcata, Phill	–	*
Astarte tremula, de Ryck.	–	*
Solemya primæva, Phill.	*	*
Arca cancellata, Mart.	*	*
Leda attenuata, Flem.	*	*
Ctenodonta undulata, Phill.	–	*
Ct. gibbosa, Flem.	*	*
Leptodomus costellatus, McCoy.	*	–
Sanguinolites striato-lamellosus, de Kon.	*	–
S. constrictus, King	*	–
S. angustatus, Phill.	–	*
S. transversus, Port.	*	–
S. iridinoides, McCoy	*	–
S. variabilis, McCoy	*	*
Edmondia rudis, McCoy	–	*
E. sulcata, Phill.	*	*
E. oblonga, McCoy	*	*
Myophoria depressa, Port.	–	*
Lithodomus dactyloides, McCoy	–	*
Pinna membranacea, de Kon.	*	–
P. flexicostata, McCoy	*	–
P. flabelliformis, de Kon.	*	–
Aviculopecten variabilis, McCoy	–	*
A. tabulatus, McCoy	–	*
A. micropteris, McCoy	–	*
A. duplicostatus, McCoy	*	–
A. interstitialis, Phill.	*	*
A. concentrico-striatus, McCoy	–	*
A. cancellatus, McCoy	–	*
A. cœlatus, McCoy	–	*
Pteronites persulcatus, McCoy	–	*
Amusium deornatum, Phill.	*	*
A. Sowerbyi, McCoy	*	–
Pecten sub-elongatus, McCoy	*	–
Conularia quadrisulcata, Sow	*	

	Great Limestone.	Four-Fathom Limestone.
Macrocheilus acutus, Sow.	–	*
M. spiratus, McCoy	*	*
M. ovalis, McCoy	–	*
M. sigmilineus	–	*
M. limnæformis, McCoy	*	–
Loxonema elongata, de Kon.	*	–
L. tumida, Phill.	*	*
L. rugifera, Phill.	*	*
L. sulculosa, Phill.	–	*
Naticopsis plicistria, Phill.	*	*
N. spirata	–	*
Euomphalus tabulatus, Phill.	–	*
E. Dionysii, Golf.	–	*
E. costellatus, McCoy	*	–
E. carbonarius, Sow.	*	*
Murchisonia quadricarinata, McCoy	*	*
M. angulata (?) Phill.	–	*
M., sp.	–	*
Pleurotomaria monilifera, Phill.	–	*
P. decipiens, McCoy	*	–
P. atomaria, Phill.	*	–
Capulus trilobatus, Phill.	*	*
Bellerophon Urei, Flem.	*	–
B. striatus, Flem.	*	–
B. decussatus, Flem.	*	*
B. navicula, Sow.	*	–
Actinoceras giganteum, Sow.	*	*
Poterioceras cornu-vaccinum, McCoy	–	*
Orthoceras undulatum, Sow.	*	–
O. sulcatum, Flem.	*	*
O. attenuatum, Flem.	–	*
O. cylindraceum, Flem.	–	*
O. inequiseptum, Phill.	*	–
O. pyramidale, Flem.	*	–
O. Goldfussianum, de Kon.	–	*
Nautilus ingens, Mart.	*	–
N. globatus, Sow.	*	–

	Great Limestone.	Four-Fathom Limestone.
N. bilobatus, Sow.	*	–
N. costato-coronatus, McCoy	*	–
N. subsulcatus, Phill.	*	*
N. biangulatus, Sow.	*	*
N. sulcatus, Sow.	*	*
N. perplanatus, Portl.	*	*
Psammodus cornutus, Ag.	–	*
Rhizodus Hibberti, Ag.	*	–

The succeeding list gives a good idea of the fauna of the Bernician beds in that part of them which corresponds to the Scar Limestone series. Many more species will probably be added to this list, as the locality is extremely rich in fossils, and has by no means been collected out.

It may be mentioned here that in a bed of limestone still lower in the series the genus *Agelacrinus*—one usually limited to Silurian rocks—has been found. An account of this fossil is to be found in the Annals of the Belgian Geological Society for 1876. It then appeared to me to be very closely allied to, if not identical with, *Ag. squamosus* of Meek and Worthen, a species represented by one single American Carboniferous specimen. Mr. W. P. Sladen, however, has since developed the fossil, and it has been figured by him in the *Quarterly Journal of the Geological Society* under the name of *Lepidodiscus Lebourii*, *Lepidodiscus* being a sub-genus of *Agelacrinus*.

List of Fossils from the Ridsdale Ironstone Beds, Northumberland:—

Chætetes tumidus, Phill.
Ch., sp.
Cyathophyllum, sp.
Clisiophyllum, sp.
Favosites, sp.
Lithostrotion irregulare, Phill.
Lithodendron junceum, Flem.
L. floriforme, Portl.

Syringopora geniculata, Phill.
Poteriocrinus (?), sp.
P. crassus.
Rhodocrinus, sp.
Woodocrinus, sp.
Archæocidaris Urei, Flem.
Arch., sp.
Hemitrypa hibernica, McCoy.
Polypora papillata, McCoy.
Ceriopora, sp.
Fenestella plebeia, McCoy.
F., sp.
Pinnatopora (Glauconome) elegans, Y. and Y.
P. retroflexa, Y. and Y.
P. flexicarinta, Y. and Y.
Acanthopora (Glauconome) stellipora, Y. and Y.
A. stellipora, var. *spinosa*, Y. and Y.
Diplopora (Glauconome) marginalis, Y. and Y.
Actinostoma fenestratum, Y. and Y.!
Hyphasmopora Buskii, R. Eth, jun.
Cystodictya (Sulcoretepora) parallela, Phill., sp.
Rhabdomeson (Millepora) gracile, Phill., sp.
Rh. (Ceriopora) rhombiferum, Phill, sp.
Athyris Royssii, L'Eveillé.
Discina nitida, Phill.
Lingula mytiloides, Sow.
L. scotica, Dav. The only English locality for this form.
L. squamiformis, Phill.
Orthis resupinata, Mart.
Orth., sp.
Productus Cora, d'Orb.
Pr. giganteus, Mart.
Pr. longispinus, Sow.
Pr. l., var. *lobatus*, Sow.
Pr. scabriculus, Mart
Pr. undatus, Defr.
Pr. Martini.
Rhynchonella pugnus, Mart.

Spirifera glabra, Mart.
S. lineata, Mart.
S. laminosa, McCoy.
Strophomena analoga, Phill.
Terebratula sacculus, Mart.
Chonetes Hardrensis (Phill., sp.).
Ch., sp.
Aviculopecten planoradiatus, McCoy.
A. papyraceus, Sow.
A. concavus, McCoy.
A. cœlatus, McCoy.
A., new sp.
Pinna flexicostata, McCoy.
P., sp.
P., sp.
Anthracosia acuta, Sow.
Axinus sulcatus, Sow.
Ax. axiniformis, Portl.
Ax. carbonarius, Sow.
Dolabra equilateralis, McCoy.
Ctenodonta tumida, Phill. (= *Nucula*).
Leda attenuata, Flem.
Edmondia arcuata, McCoy.
E. quadrata, McCoy.
E. sulcata, Phill.
Mytilus Flemingii, McCoy.
Myacites Austinei, Sow.
M. primæva, Portl.
M. sulcata.
M., sp.
Sanguinolites curtus, McCoy.
S. iridinoides, McCoy.
S. plicatus, Portl.
S., sp.
Conularia quadrisulcata, Sow. **This is much commoner at Hareshaw (in the same beds) than at Ridsdale.**
Macrocheilus canaliculatus, McCoy.
Euomphalus, sp.

Bellerophon decussatus, Flem.
B. Urei, Flem.
B., sp.
Goniatites obtusus, Phill.
G. sphæricus, de Haar.
G. truncatus, Phill.
G., sp.
Cyrtoceras Gesneri, Mart.
Discites sulcatus, Sow.
Orthoceras ovale, Phill.
Or., sp.
Discites subsulcatus.
D., sp.
Cladodus striatus, Ag.
Gyracanthus tuberculatus, Ag.
Helodus lævissimus, Ag.
Psammodus reticulatus.
P. porosus, Ag.
P., sp.

Specimens of all these species from this rich locality are preserved in the Newcastle Museum, and in that of the Durham College of Science.

The interesting fossil *Posidonomya Becheri* occurs at Budle and in the neighbourhood of Alnwick, and appears to be confined to the Upper Bernician series.* Its exact horizon is still doubtful.

The occurrence of *Anodonta Jukesii* in the grits which in Northumberland form a passage from the Tuedian to the Bernician series has been referred to in the earlier portions of this little work (p. 78).

The two next lists are very complete as to the microzoa, and for them I have to thank the Rev. Mr. Howchin, F.G.S., of Haltwhistle, who kindly washed the material collected by me, and determined the species. The Scremerston Limestone is one of the lowest in the series, while that at Lamberton is the "Dun Limestone" which—as has been explained already (p. 77)—is taken, near Berwick, as the base of the Bernician rocks.

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* See Lebour "On the *Posidonomya Becheri* Beds at Budle, Northumberland," in the *Geological Magazine* for January, 1885,

A List of Fossils observed in a washing taken from a band in the Scremerston Limestone, South of Berwick:—

Climacammina antiqua, Brady, very rare.
Endothyra Bowmani, Phill., rare.
E. radiata, Brady, rather scarce.
Stacheia polytrematoides, Brady, rather scarce.
Textularia eximia, d'Eich., very rare.
Trochammina incerta, d'Orb., common.
Valvulina palæotrochus, Ehrenb., rare; var. *compressa*, moderately common.
V. decurrens, Brady, common.
V. plicata, Brady, very rare.
Stenopora tumida, Phill.
Archæocidaris, sp., very small spines.
Encrinital remains.
Spirorbis globosus (?), McCoy.
Entomostraca, common.
Glauconome flexi-carinata, Y. and Y.
Hyphasmopora Buskii, Eth.
Rhabdomeson gracile, Y. and Y.
Rh. rhombiferum, Y. and Y.
Chonetes Buchiana (?), de Kon.
Lingula, sp.
Productus semireticulatus, Mart.
Spirifera glabra, Mart.
Sp., sp.
Streptorhynchus crenistria, Phill.
Loxonema polygyra (!), McCoy, cast.
Ctenoptychius serratus, Ag.
Numerous small fish remains.

A List of Fossils observed in a washing taken from the Lamberton Limestone, three miles North of Berwick:—

Archædiscus Karreri, Brady, rare.
Endothyra radiata, Brady, rare.
Saccammina Carteri, Brady, single specimen.
Stacheia acervalis, Brady, rare
St. congestu, Brady, rare.
St. fusiformis, Brady, rare.
St. polytrematoides, Brady, rather scarce.
Trochammina incerta, d'Orb., very common.
Valvulina decurrens, Brady, moderately common.
V. palæotrochus, Ehrenb., common.
V., var. *compressa*, rare.
V. plicata, Brady, rather scarce.
Stenopora tumida, Phill.
Archæocidaris, sp., plates.
Encrinital, stems, etc.
Ortonia carbonaria, Young.
Spirorbis, sp.
Entomostraca, rather scarce.
Ceriopora interporosa, Phill.
Fenestella, sp.
Glauconome marginalis, Y. and Y.
Gl. retroflexa, Y. and Y.
Gl., sp.
Hyphasmopora, sp.
Polypora, sp.
Sulcoretepora parallela, Phill.
Spirifera, sp.
Productus giganteus, extremely abundant.

Bernician Foraminifera of Northumberland, after Mr. H. B. Brady, F.R.S.:*—

Archædiscus Karreri, Brady.	Lower Bernician (= Scaur Limestones).

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* See Brady's "Monograph of Carboniferous and Permian Foraminifera."—Palæontographical Society's Publications for 1876.

Bigenerina patula, Brady.	Upper Bernician (= Yoredale Beds).
Endothyra ammonoides, Brady.	Upper and Lower Bernician.
E. Bowmani, Phill.	,, ,, ,,
E. crassa, Brady.	Lower Bernician.
E. globulus, Eichw.	Upper and Lower Bernician.
E. macella, Brady.	Upper Bernician.
E. obliqua, Brady.	Upper and Lower Bernician.
E. ornata, Brady.	,, ,, ,,
E. radiata, Brady.	,, ,, ,,
Lagena howchiniana, Brady.	,, ,, ,,
L. lebouriana, Brady.	Upper Bernician.
L. parkeriana, Brady.	,,
Lituola nautiloidea, Lam.	Lower Bernician,
Saccammina Carteri, Brady.—(Characteristic of the Four-Fathom Limestone, but also found at other horizons).	Upper and Lower Bernician.
Stacheia acervalis, Brady.	Upper Bernician.
St. congesta, Brady.	Upper and Lower Bernician.
St. fusiformis, Brady.	,, ,, ,,
St. polytrematoides, Brady.	,, ,, ,,
St. pupoides, Brady.	,, ,, ,,
Textularia eximia, Eichw.	,, ,, ,,
T. gibbosa, d'Orb.	,, ,, ,,
Trochammina anceps, Brady.	Upper Bernician.
Tr. annularis, Brady.	,, ,,
Tr. centrifuga, Brady.	Upper and Lower Bernician.
Tr. gordialis, Park and Jones.	Upper Bernicians.
Tr. incerta, Brady.	Upper and Lower Bernician.
Valvulina palæotrochus, Ehreub.	,, ,, ,,
V. plicata, Brady.	Lower Bernician.
V. Youngi, Brady.	,, ,,

Mr. Vine, of Sheffield, has published some interesting lists of Entomostraca and Foraminifera from what he calls the "Northern Shales" in the *Naturalist* for 1884 and 1885. These shales, however, are simply the Ridsdale ironstone shale, and as the lists refer merely to neighbouring localities (not different horizons) in this shale, it has not been thought necessary to reprint them.

For the Entomostraca some papers recently published by Professor T. Rupert Jones, F.R.S., in the *Berwickshire Naturalists' Club Proceedings*, and in the *Geological Magazine*, should be consulted. A large field is still open, nevertheless, for workers in the micro-Palæontology of the Lower Carboniferous rocks of the North of England. I was gratified to see that Professor Rupert Jones had made use of the term Bernician in forming the new genus *Bernix* and the species *berniciana*.

We conclude with a list of those Carboniferous Limestone fossils which are quoted by d'Orbigny as occurring in Northumberland :—

Carboniferous Fossils recorded from Northumberland in d'Orbigny's *Prodrôme* (1850) :—

In this list the locality "*Harelaw*" is supposed, in some cases, to be a misprint for *Hareshaw*.

Nautilus Phillipsianus, d'Orb. (= *sulcatus*, Sow., 1826, non *sulcatus*, Risso, 1825).
N. tetragonus, Phill.
Cyrtoceras rugosum, de Kon. (= *Orth. annulatum* and *rugosum*, Phill.)
Loxonema rugifera, Morris (= *Chemnitzia rug.*, de Kon., and *Melonia rug.*, Phill.)
Macrocheilus acutus, Phill. (= *Buccinum acutum*, Sow., *M. ovalis*, McCoy, and *Littorina pusilla*, McCoy.
Natica elliptica, Phill.
N. plicistria, Phill. (= *Nerita plicis.*, de Kon.)
N. ampliata, Phill. (= *Nerita ampl.*, de Kon.)

Straparollus pentangulatus, d'Orb. (= *Euomphalus pent.*, Sow.)
Str. tabulatus, d'Ord. (= *Euomph. tabulatus*, Morris, and *Cirrus tabulatus*, Phill.)
Murchisonia triserialis (?), d'Orb. (= *Turitella triser.*, Phill.)
Pleurotomaria vittata, Phill., Otterburn.
Pholodomya sulcata, d'Orb. (= *Sanguinolaria sulc.*, Phill.)
Lyonsia arcuata (?), d'Orb. (= *Sanguinolaria arcuata*, Phill.), Harelaw.
Solemya primæva (?), Phill.
Leda claviformis, d'Orb. (= *Nucula clavif.*, Sow.), Harelaw and Otterburn.
L. brevirostris, d'Orb. (= *Nacula brevir.*, Phill.), Harelaw.
Cypricardia tumida, d'Orb. (= *Nucula tum.*, Phill.)
C. rhombea, Phill. (= *Cy. glabrata*, Phill., and *Cy. bipartita*, de Kon.)
Cardiomorpha elliptica, de Kon. (= *Venus elliptica (?)*, Phill.)
C. axiniformis, d'Orb. (= *Isocardia axiniformis*, Phill., and *Nucula luciniformis*, Phill.)
Pinna granulosa, d'Orb. (= *Modiola granul.*, Phill.)
Lingula parallela, Phill.
Productus giganteus, Sow.
Pr. latissimus, Sow.
Pr. Cora, d'Orb., Lowich.
Pr. semireticulatus, Flem.
Pr. costatus, Sow., Lowick.
Pr. Flemingii, Sow.
Pr. scabriculus, Sow., Harelaw.
Pr. punctatus, Sow., Otterburn and Lowick.
Pr. fimbriatus, Sow.
Chonetes sulcata, de Kon., Lowick.
Ch. tuberculata, de Kon. (= *Leptæna tuberc.*, McCoy), Lowick.
Strophomena depressa, d'Orb. (= *Leptagonia depressa*, McCoy, *Producta depressa*, Sow., and *Leptæna depressa*, de Kon.)
Spirifera duplicostata, Phill. (= *Sp. furcata*, McCoy).
Sp. integricosta, Phill.
Sp. duplicicosta, Phill.
Sp. trigonalis, Sow. (= *Sp. transiens*, McCoy).
Sp. bisulcata, Sow. (= *Sp. semicircularis*, Phill.)

Spirigera ambigua, d'Orb. (= *Spirifer ambiguus*, Sow., and *Terebratula ambigua*, de Kon.)
Terebratula sacculus, Mart. (= *Ter. hastata*, Phill.), Otterburn.
Orbiculoidea nitida, d'Orb., Harelaw, Otterburn.
Diphyphyllum irregulare, d'Orb. (= *Lithodendron irreg.*, Phill.)
Chætetes septosus, de Keys. (= *Favosites septosus*, Flem.)

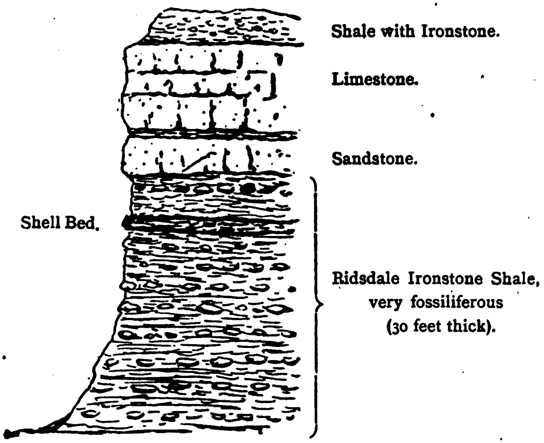
REMARKS ON THE FOREGOING LISTS.

Disconnected as these lists are, they may yet be of value in the absence of the fuller and more critical material which it is hoped professed palæontologists will in time provide us with. I would especially insist upon the fact that, so far, no *common* fossil has been found in the Lower Carboniferous rocks of Northumberland and Durham sufficiently restricted in its range to serve as a characteristic fossil of any subdivision. This being so, and no important unconformity being met with between the base of the Tuedians and the Millstone Grit, all subdivisions within these limits must necessarily be lithological. Being lithological, they can be local only, and this is especially the case in the Bernician area, where the Carboniferous deposits are all of a rapidly alternating character, showing proximity to land and continually changing conditions.

Productus giganteus and the other common species of the genus, in other Carboniferous regions distinctly characteristic of certain portions of the series, are found in large numbers in Northumberland and Durham wherever the limestones or calcareous shales are of a clearly marine type from the Fell-top to the beds next the Rothbury Grits. The Spirifers are similarly distributed, and the same is the case with all the genera and species of common occurrence in the limestones, whether the latter be thick or thin.

The Ridsdale locality is especially instructive in this respect, since it lies at the very line which has been taken as the boundary between the "Calcareous" and "Carbonaceous" divisions of Tate's classification. Here the section, admirably exposed in the old ironstone quarries at Skelly Gate and thereabouts, is as shown in the subjoined figure.

FIG. 16.—*Section of the Beds exposed in the Ridsdale Ironstone Pits (Lower Bernician).*


Shale with Ironstone.
Limestone.
Sandstone.
Shell Bed.
Ridsdale Ironstone Shale, very fossiliferous (30 feet thick).

The limestone in this section is known in the district as the "Bottom Limestone," but it is the same, probably, as the Hobberlaw Limestone of the Alnwick district, which Tate regarded as the lowest bed of his "Calcareous" division of the Carboniferous Limestone series. The beds beneath this bed, therefore, belong to the Lower or "Carbonaceous" division. Now it fortunately happens that the limestone and the shale are both exceedingly rich in fossils, and that both have been collected in largely. Nevertheless there is not a *common* fossil in either bed which cannot be equally found in the fossiliferous shales and limestones above and below the supposed line of demarcation, from the Felltop Limestone to the Lewis Burn beds. Shales holding similar forms are well known at

Brinkburn and Chesterholm, higher up in the series, and at the Belling, Plashetts, Smales, etc., lower down. Limestones holding the same forms are likewise found above and below, though they are undoubtedly commoner above, such beds being thicker than below, where they are thin and often impure. The rarer fossils, however interesting in themselves, can, of course, have no classificatory value.

The horizon marked "Shell Band" in the figure is a calcareous ironstone band entirely made up of shells, layers of Pectens and Brachiopods predominating, but accompanied by many other forms, and the hollow needle-like *Productus* spines generally forming a matted background to the mass. The ironstone formerly worked occurs as irregular nodules of clay ironstone lying irregularly in the shale both above and below the shell band, and often containing fossils within as well as without.

Next to the Ridsdale fossils those of the Great and Four-Fathom Limestones claim more than passing notice, not only by their abundance and variety, but because the beds in which they are found are so clearly traceable across the country, and almost everywhere so easy of access. The Lowick Quarries, in which the late Rev. E. Jenkinson obtained his fossils, are still open and yield numerous fossils, whilst at Fourstones and Brunton a great deal of good collecting may still be done. In the neighbourhood of Alnwick, also, large quarries are opened in these beds, especially at Denwick Lane, where the rare annelid cases (*Serpulites carbonarius*) are always to be found, together with numbers of other specimens. In Durham the large quarries of Teesdale and Weardale are inexhaustible store-houses of limestone fossils; but the shales appear not to be so rich as those of Northumberland, which are thicker, more numerous, and often calcareous.

A thin limestone which crops out in the boggy region about the Irthing, South of Hope House, and is, therefore, low down in the Bernician, is full of *Lithostrotion Portlocki*, a coral which, so far as I am aware, is only found as abundantly in the Felltop Limestone at Harlow Hill.

The vertebrate remains of the Bernician rocks have not been much studied. This is to be regretted, for, from the little that is known about them, it seems probable that they would be found to be more restricted in their ranges than the invertebrates. The few fish remains which I have collected in the series have always been different in different places, but this, of course, may be mere accident.

Except for plants, the sandstones and grits are not usually inviting to collectors; but there are exceptions to this rule. Thus, in the Inghoe Grits, are several thin bands of closely packed *Orthidæ*, and in the Rothbury Grits, near Chillingham, the fine specimens of *Anodonta Jukesii*, now in the Newcastle Museum, were found, etc.

Indeed, collectors are comparatively scarcer than fossils in Northumberland and Durham, and if the many competent local naturalists were to direct their attention to careful fossil-hunting—each in his own immediate neighbourhood—the lists to publish would soon, I am sure, cease from being as meagre as they are, and natural subdivisions of the great Carboniferous Limestone series of Bernicia might become possible. To willing collectors who may not know how to start I would say:—Collect as many specimens as you can find; do not be afraid of accumulating duplicates—a defective fossil in one particular is often most valuable in another, and varieties can only be studied by means of numerous specimens of each species; carefully record not only the locality where each specimen is found, but as nearly as possible its exact position in the rock-face or section. This can generally be easily done by means of a sketch, in which each layer in each bed is numbered. Lastly, do not be in a hurry to name your specimens. Only experts in each group of organisms can, in these days of enforced specialisation, in science know more than a limited number of *species* at sight.

CHAPTER XV.

FAULTS AND VEINS.

IT is not my intention to do more than allude to some of the principal dislocations of the strata in the district under consideration. That there are a very large number of them will be seen at once on glancing at any colliery plan or detailed geological map of the coal-field. There are at least as many (probably many more) in those parts of the two counties which are occupied by the older rocks, but of these comparatively few only will be found laid down on the maps, except in the lead-mining districts. The reason of this is that minor faults—and sometimes even large faults—are often difficult to find and to map unless they be proved by mining operations. Very few even of the largest faults in the North-country (the great Penine fault or faults excepted) cause or are accompanied by any surface feature, and in many cases they are concealed by Drift deposits. Thus the apparent absence of faults in maps representing rocks older than the Coal-Measures must be taken for what it is worth. The case is different as regards the rocks above the Coal-Measures, where a still greater freedom from lines of dislocation is apparent. The fact is, that by far the greater amount of faulting took place in pre-Permian times, and the Permian rocks are therefore really much less dislocated than those on which they lie. If follows from this that faults proved in collieries worked in Durham beneath the Permian often fail to reach the surface altogether.

It should be mentioned that in Northumberland and Durham the word *dyke* is frequently used as a synonym for *fault* where there is no intrusion of igneous material. The Ninety-Fathom Dyke (see pp. 5 and 35, and Plate II., Figs. 1 and 2) and the Stublick Dyke (pp. 5 and 51), already referred to, are cases in point. The former is a good example of a great *post*-Permian fault. Its downthrow to the North is in one part of its course over 1,200 feet.

In Fig. 2 of Plate II. only the larger faults affecting the coal-field are shown. This is an instructive section. It shows very clearly the general neutralising effect of the faults—each great throw in one direction being compensated by one or more in another—so that, looking at the figure as a whole, the general gentle synclinal curve of the Coal-Measures is seen to be only locally disturbed by the earth-fractures represented. The large fault marked near the Southern extremity of the section is a good example of a *pre*-Permian disrupture.

As was to be expected, the two chief directions of the igneous dykes (see p. 85) are also those affected by the majority of the larger faults. There is an East and West and a North-East and South-West series with them as with the dykes, though, of course, the exceptions to the rule are numerous.

To the East and West series belong a number of important faults which run inland from the coast, and which, where the latter is abrupt, can often be splendidly seen in section in the cliffs, as in the Coal-Measure sandstones between Cullercoats and Seaton Sluice, or in the Bernician beds at Howick. Several of these great faults, however, are not visible on the coast-line, but reach the shore where it is flat and sandy, and so common is this arrangement that it may be said that almost every sandy bay between the Tweed and the Aln marks the line of a fault. A good instance of this state of things, and of the kind of observation and reasoning by which such faults can with certainty be inferred, has recently been described by me.* It may be noted in passing that these East and West faults, being across the general strike, are necessarily much more easily discovered and traced than those of the second series.

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* "On a large Fault at Annstead, in Northumberland."—*Transactions of the North of England Institute of Mining and Mechanical Engineers*, 1884. This fault has a throw of more than 800 feet.

The latter, running—as they do—parallel to the strike, repeat the beds, and therefore often escape detection. It is owing to faults of this kind with large throws—often exceeding 1,000 feet—that the great Rothbury Grits group are repeated so finely in Western Northumberland, forming the Harbottle Grits and the many bold crags to the North of them about Chillingham. Such a repetition was scarcely suspected until it was proved by the patient skill of Mr. Hugh Miller, F.G.S., and the other officers of the Geological Survey. The recognition of the identity of so many scarped beds formerly supposed to dip one beneath the other is one of the most important additions to our knowledge of Northumbrian geology made in recent years.

It is not, however, the large faults only which are of interest to the geologist. The small *slips*, *hitches*, and *troubles* so constantly met with in collieries present an almost endless field of observation. Many of these minor disturbances are but the dying-out portions of larger ones, and accurate records of them are often of much importance from a practical as well as from a scientific point of view. Many problems respecting such dislocations are still unsolved which the comparison of careful records would no doubt explain; but in this district, though skilled observers are plentiful, those who will take the trouble to record their observations are still few. The several small faults recently described by Messrs. T. O. Robson and M. Walton Brown as occurring in one of the seams in Redheugh Colliery, Gateshead, and as not being traceable in the workings of a seam a short distance below it, are a good example of the kind of observation required.* The infillings of the faults is another point respecting which all information would be welcome, as it is likely to throw much light upon the formation of some mineral veins.

Where a fault is also a fissure of any width the space between its cheeks is filled up more or less completely (*a*) with material fallen in from above or from the sides; (*b*) with material deposited chemically from above or from the adjoining rocks; or (*c*) with material deposited chemically from below. Faults of the third group are the mineral veins of the metalliferous districts of Tyneside, Allendale, Derwent, Alston, Weardale, and Teesdale, and they usually combine the characters of the groups (*a*) and (*b*) as well. Faults of the two last-named types are, however, common outside those districts. Fig. 17 is a good example of the (*a*) type, and fault-veins filled with calcite are the rule in the Bernician series. Others filled with barium sulphate are known both in these beds and in the Coal-Measures. At Lumley Colliery, for instance, a fault-fissure has recently been struck, having a width of 8 ft. filled with pure white barium sulphate. That such veins are commoner than is supposed is inferred from the fact (long known but hitherto unexplained by chemists) that the deposits formed in water pipes in so many collieries of the district often consist largely of barite. The "Sunday Stones," as these banded deposits are often called, of Harton and Walker collieries are among the best known of the kind. Lead ore is also found not unfrequently in connexion with such faults beyond the lead-mining regions proper, though seldom—if,

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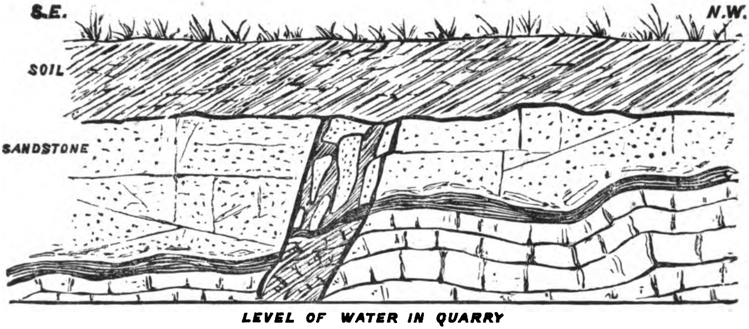
* See papers read at the Durham College of Science Geological Club in the spring of 1886.

FIG. 17.—*Section in North Sunderland Quarry, showing infilling of wide fissure-fault.*



indeed, ever—in quantities of commercial importance. Thus galena in fine crystals has from time to time been brought to my notice from collieries South of the Wansbeck by Mr. R. Spence and others. Occasionally the occurrence of lead is associated with the presence of igneous rock. This was the case at Hartley.

On approaching the Western half of the two counties, however, the infillings of the faults become more and more metalliferous, and the true lead-vein district begins. The rocks in which the ore is generally found are the Bernician beds from the Great Whin Sill upwards. Some has been worked at times in the beds below the Whin and in the Millstone Grit, but seldom profitably. The more valuable veins belong to the North-East and South-West series, and are known as cross veins by the lead miners. The throw of some of the best is sometimes extremely small, as is well shown in the case of the Derwent Mines in the neighbourhood of Blanchland. The following are some of the principal veins, viz.:—The Whiteheaps Vein, in Derwent; the Great Burtreeford Dyke, a most important fault, with a throw in places of some 500 feet, and running from the Yorkshire side of the Tees through Weardale to Allenheads; Whetstone Mea, in the Allenheads and Coalcleugh district; the Fallowfield Vein, crossing the North Tyne near Warden Mill, and having a considerable throw down to the North; the Bavington vein, in the Whin Sill some miles East of the North Tyne, near the hamlet of Bavington; the Kirkwhelpington Veins, crossing the Upper Wansbeck, also in the Whin Sill; veins at Ridpath and Hartington, both North of the Wansbeck; the Langley Barony, Stonecroft, and Settlingstone group of veins, North of Haydon Bridge; Bounder End, Moss, and Handsome Mea Veins, in the Coalcleugh district; Old Carr's Cross Vein, the richest in Alston Moor, with a maximum throw of 250 feet; Black Ashgill and Sir John's Veins, in the Ashgill and Nenthead districts; the Sulphur Vein, or Great Backbone of the Earth, as it is called by the miners, containing much iron pyrites with some copper ore, crosses the South Tyne at Tynehead. The last-named vein is one of the very few in the district showing any promise as a copper lode. A fault-vein, containing copper pyrites and malachite in appreciable but not in paying quantities, has long been known in the Permian Magnesian Limestone at Raceby Hill Quarries, in Durham.

The vein-stuff in the lead district varies according to locality. Thus it has been noticed that whereas in Teesdale and West Allendale the veins West of the Great Burtreeford Dyke contain much barium sulphate, those to the East of it contain chiefly calcite and fluor-spar. The Fallowfield and Settlingstones veins above-mentioned are remarkable for the amount of witherite or barium carbonate which they have yielded. The width of the latter vein is sometimes as much as 17 feet.

Zinc blende occurs very frequently in the lead-veins of Alston and Teesdale, much less commonly in those of Weardale and the Derwent.*

Some prospecting for ore-bearing veins has occasionally been carried on in the hilly district in North-Western Northumberland, but without much success. In 1871, however, I found a well-marked lead vein in the Cheviot porphyrites at Raven Cleugh, a few miles from Alwinton, and a few others are known in the Lower Carboniferous rocks skirting the volcanic rocks in the neighbourhood of Ingram. There is, however, at present no promise of these regions ever becoming paying mining fields.

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* For much valuable information on all matters connected with the metalliferous veins of the North see Westgarth Forster's classical "Treatise on a Section of the Strata from Newcastle to Cross Fell," of which a new edition was published in 1883, and Wallace's book on the Alston Moor Mining District.

CHAPTER XVI.

SUMMARY OF THE GEOLOGICAL HISTORY OF NORTHUMBERLAND AND DURHAM

IT has been suggested that a brief chronological summary of the geological history of Northumberland and Durham would be useful, more especially as the various systems have been described in this book in descending order, and not in that of their formation.

1.—The earliest state of things of which we possess records is a Silurian sea occupying probably the entire region, in which fine sediment was quickly accumulating—sometimes sandy and now represented by greywacke grits, but more often muddy and represented by shales and clay-slate. That this sea was inhabited by a large and varied invertebrate fauna in other parts of the British area is well known, but here a scanty group of lowly graptolites and annelids is all of which traces have as yet been found. Towards the close of this great marine period probably volcanic activity set in, of which we have evidence in the dykes of mica-trap or minette in Teesdale and at the foot of the Penine Escarpment, and possibly in much of the disturbed position in which we find the beds which they traverse.

2.—Succeeding to the Silurian sea came a period of emergence during which the various agents of denudation were busy planing down and eroding the surface of the previously folded deposits of that sea. This was a long era of non-deposition, concerning which the evidence is necessarily to a great extent negative. The worn down edges of the rocks are, however, sufficient witness.

3.—The next age of which we have any knowledge in this region is that of the Old Red Sandstone, represented here, however, scarcely at all by the ordinary conglomerates and sandstones of that series, but by the thick lavas and ashes of a great volcano or group of volcanoes. The rocks accumulated from this vent or vents are still there to attest the size and importance of this great eruptive centre, and form the large area of igneous rocks called the Cheviot Hills, and situated near the edge of the Old Red Sandstone Lake Cheviot. It is possible that in later times this centre was more than once again active, and there can be little doubt that some of the disturbances affecting the rocks both above and beneath them are due to its action.

4.—Another, but shorter, time of denudation now supervened, which is marked in Scotland by a plane of unconformity between the Lower and Upper Old Red Sandstone, but which in Bernicia has not left very striking proof ot its existence, unless it be the fragments of Cheviot rocks which go to form to a certain extent the succeeding set of deposits.

5.—These are the Basement Beds of the Carboniferous system, which are, as has been before described, coarse conglomerates formed along the shores of the volcanic Cheviot volcano, then becoming a slowly sinking island, and consisting chiefly of *débris* from the wasting high ground.

6.—Then follows the extraordinary repeated alternations of open sea, land-locked sea, lake, land, estuary, and shore to which we owe the thousands of feet of grits, shales, underclays, coals, and limestones which go to make the great Carboniferous system as it is represented in the Tuedian and Bernician country. Whether these alternations were in all cases due to oscillations of the earth-crust is open to doubt, but the effects are such as would result from such oscillation. A few horizons mark some of the greater changes in this long and, on the whole, wonderfully uniform succession of strata. Thus the conglomerates at the base herald the Tuedian land-locked sea or lake era, during which, at one time, volcanic action was strong in Scotland and at the very Border, as evidenced by the felsitic rocks of Carham. In the same way the constantly interrupted yet marked marine condition of the Bernician series was ushered in by a great accumulation of coarse shore or shallow sea grits—the Rothbury Grits. So also the Inghoe Grits at the top of the Bernician, with the Millstone Grit and the Coal-Measures, mark the close—for this area—of strictly sea conditions. Of volcanic action during the enormous time represented by this mass of deposits there is no absolutely certain evidence, but it is possible that the Great Whin Sill and some of the basaltic dykes may have been erupted during later Carboniferous ages, though there is some reason to regard them as a little younger.

7.—The well-marked denuded edges of the Coal-Measures, Millstone Grit, and Bernician beds upon which the Permian rocks are laid offer all the requisite proof of another period of general emergence and consequent denudation. During this time, also, most of the faulting of the region seems to have taken place.

8.—First, as usual, of new deposits are gritty beds—the Yellow Sands of the Permian—irregularly distributed in the hollows of the Carboniferous plain of denudation. Then the fish-laden waters of the Marl-Slate, succeeded by the land-locked strangely-conditioned sea of the Magnesian Limestone with its odd and meagre fauna of stunted marine forms.

9.—In the Durham region, at least, there next succeeded a time of sand deposition and small inland seas gradually evaporating into salt lakes, and leaving behind it more than a thousand and a half feet of red sandstones, with gypsum, anhydrite, and valuable beds of rock-salt. These are the Upper (Rauchwacke) Permian and the Trias of South Durham and the lower Tees flats. But within these 1,500 feet of rock there may be evidence, not yet brought to light, of one or two periods of denudation, each giving rise to an unconformity.

10.—In North Yorkshire, but not in Northumberland or Durham, we have ample tokens of the quiet and regular succession over the Trias of more truly marine conditions in Rhætic and Liassic time, replaced in turn by land and estuaries (Inferior Oolite), but whether these post-Triassic seas extended much North of the Tees there is nothing to show. For the region dealt with here there is, therefore, a huge hiatus in its geological history. Of what took place from Triassic times to the close of the Pliocene, whilst the Jurassic, Cretaceous, and Tertiary rocks were being accumulated elsewhere, we know nothing—merely guessing, by analogy, that some of the basaltic dykes may have been erupted in Triassic, others in Tertiary (perhaps Miocene) times.

11.—The great lapse of time to which this gap in the series of deposits is equivalent was certainly taken up to a considerable extent by denudation, and most of the broader sculpturing of the two counties—most of the surface features—had already been graven by sea, rain, and rivers when the cold of the last great glacial epoch crept over Britain and left its mark in the boulder clays and drift sands and gravels, filling up old valleys, and covering the lower parts of the country as with a cloak of ice-borne or ice-worn material. This was the time when Britain, though partly submerged as to the ground adjoining its coasts, presented, on the whole, the aspect worn by Greenland at the present day.

12.—As the severe cold by degrees gave place to a milder climate the snow line was gradually pushed back higher and higher up the hills, forming the ever-diminishing glaciers which are now extinct, but which have left some of their moraine heaps well-preserved behind them.

13.—Lastly, from all these changes the present state of things comes forth—a period of denudation once more, but one in which man, the last comer, is rapidly becoming almost as powerful an agent as wind, river, frost, or rain.

CHAPTER XVII.

THE CLEVELAND IRONSTONE DISTRICT.

THE Cleveland Hills rise so few miles beyond the Tees, and are of such importance from a practical point of view in connection with the great Northern Coal-field, that a short reference to their geological structure—outside Durham though they be—will, it is hoped, not be considered out of place in this work.

A glance at Plate IV., Fig. 1, will show that these hills are formed of low-dipping, perfectly regular layers of rock belonging to the Lias and Lower Oolite, and resting quite conformably upon the Rhætic beds which, as explained in Chapter V. (p. 28), were some years ago proved to occur at the top of the Triassic Red Sandstones at Eston.

The Yorkshire Lias has been divided in several ways. By palæontologists it is regarded as consisting of a number of zones, each of which is characterised by one or more fossils (generally certain species of the large genus *Ammonites*); by non-palæontological observers it is more often divided according to the varying lithological character of the stone; by others, again, a classification based upon both palæontological and lithological characters is adopted. In any case a division of the series into three is generally recognised, viz.:—

1.—*The Lower Lias*, which is clayey or shaly, with thin limestones and numerous bands of oysters (*Gryphæa arcuata*) and other bivalves (*Cardinia Listeri*). This can be excellently studied at Redcar on the scars left uncovered at low tide, and its outcrop, owing to the very low dip, occupies the low ground along the coast from that place past Marske to close to Saltburn.

2.—*The Middle Lias*, which, as to its lower part, is very like the last in appearance, but the commoner oysters in which (*Gryphæa cymbium*), though closely allied to those of the Lower Lias oyster banks, are yet of another species and not arranged in such thick or close-set layers. The shales of the Middle Lias soon become less and less clayey as we rise in the series, and gradually give place to more or less massive beds of sandstone and what is not very properly termed marlstone, and towards the top to the ironstone deposits which have made Cleveland famous. The fossil characteristic of the ironstone is *Ammonites spinatus*. It is the Middle Lias which forms the fine section exposed at Huntcliff.

3.—*The Upper Lias*, which is chiefly shaly, and in the upper portion consists of shale so thinly laminated as to deserve the name "paper shales." It is in the upper part of this division that jet is found, which has for so long a time been regarded as beyond all others a Yorkshire coast product. It is also these shales which formerly—not very long ago—fed the large alum works of the district. For this reason the name "Alum Shales" is sometimes given to the Upper Lias. The old alum workings can be seen at Boulby and Rockcliff (the last the highest English cliff) and those of jet under the brow of the flat-topped hills which shelter Guisborough to the South and run West to Roseberry Topping.

The Inferior Oolite in all cases caps the Lias in this region, and is here a yellowish sandstone of variable grain, with plentiful remains of drift wood.

The following table will show side by side the modes of dividing the Lias above referred to :—

Inferior Oolite.

		Ft.	In.	(Ammonite Zones.)
Upper Lias	Alum shale series	115	0	*Amm. communis.*
	Jet Rock series	48	0	,, *serpentinus.*
	Grey shale with doggers	30	0	,, *annulatus.*
Middle Lias	Ironstone (main seam)	11	6	,, *spinatus.*
	Shale with doggers	10	6	
	Ironstone (bottom seam)	2	9	,, *margaritatus.*
	Shale with nodules	20	0	
	Ironstone in thin bands	1	9	
	Shale with doggers	30	0	
	Sandstone, flaggy, calcareous, and ferruginous (the MARLSTONE)	40	0	
	(This line is often taken as the boundary between the Lower and Middle Lias.)			
	Shales with numerous thin bands of Limestone and Oyster banks	700	0	,, *capricornus.* ,, *Jamesoni.*
Lower Lias				,, *armatus.* ,, *oxynotus.* ,, *Bucklandi.* ,, *angulatus.* ,, *planorbis.*

Avicula contorta or *Rhætic Beds.*[*]

The ironstone is an earthy carbonate of iron, often covered with fossils. It is generally of a bluish colour, or (near the base) greenish grey where unaltered, but at the outcrop it is often altered to a brown hydrated peroxide. The average percentage yield of metallic iron is 30 per cent., and the main seam where thickest—at Eston—locally attains some 15 feet. The area occupied by this valuable bed is calculated at about 350 square miles, of which, however, perhaps not more than 70 square miles can be profitably worked.* Towards the South-East the main seam of ironstone splits up into a number of thin seams separated by shales.

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[*] The thicknesses given in this table are, of course, subject to much local variation. They are taken from Mr. J. D. Kendall's paper "On the Iron Ores of the English Secondary Rocks," the most recent on the subject.—*Transactions of the North of England Institute of Mining and Mechanical Engineers*, Vol. XXXV., p. 113 (publishsd July, 1886).

Ayton, Nunthorpe, Newton, Guisborough, Ormesby, Eston, Kirkleatham, Redcar, and Marske stand upon Lower Lias. The Middle Lias (with the ironstone) forms all but the uppermost portions of the peninsular ridge which runs from Saltburn by Hobb Hill; Upleatham, and the Eston Mines to Normanby, and which separates the Redcar flats from the Guisborough valley, thence it crops out by Skelton, Slapewath, and Hutton to Roseberry, thus surrounding Guisborough on three sides. From Roseberry the Middle Lias trends away to the South-West. The Eston mass of ironstone is, indeed, a long outlier, due to denudation aided by some North-West and South-East faults, which are well known and can be well studied in detail in Messrs. Tate and Blake's classical work on "The Yorkshire Lias" (1877), after whom the sketch map is taken (see Plate V.)

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* *Op cit.*, p. 114.

APPENDIX.

AT the meeting of the British Association, held at Birmingham in September this year (1886, an interesting paper was read by Mr. Hugh Miller, F.G.S., of H.M. Geological Survey, " On the Classification of the Carboniferous Limestone Series: Northumbrian Type." The gist of the paper is the accompanying scheme, which, it will be seen, differs in many respects from that adopted in the present work. It will be useful for comparison, and the thicknesses given are valuable.

CARBONIFEROUS LIMESTONE SERIES: NORTHUMBRIAN TYPE (Northumberland, East Cumberland, and Liddisdale).

		Feet.
Upper Limestone Series.	*Felltop or Upper Calcareous Division:—From the Millstone Grit to the zone of the Great Limestone.* Sandstones and shales; one or more beds of marine limestone, including the Felltop Limestone; some coals	350–1,200
	Calcareous Division:—From the Great Limestone to the bottom of the Dun or Redesdale Limestone. Many beds of good marine limestone; sandstones and shales; coals	1,300–2,500

		Feet.
Lower Limestone Series.	*Carbonaceous Division (Scremerston Beds of North Northumberland):—From the Dun or Redesdale Limestone to Tate's "Tuedian Grits."* Strata prevalently carbonaceous; limestones chiefly thin, many of them containing vegetable matter; coals	800–2,500
	Tuedian Division:—Upper Tuedian or Fell Sandstone Group, the "Tuedian Grits" of Tate:—From the Carbonaceous Group to the Cement-Limestones. Great belt of massive grits (Tweedmouth, Chillingham, the Simonside and Harbottle Hills, the Peel, and Bewcastle Fells). Shales, greenish and reddish as well as carbonaceous grey; coals rare, thin, or absent ...	500–1,600
	Lower Tuedian or Cement-Limestone Group:—From the base of the Grits downwards. Cement-stone bands passing into limestones (Rothbury, Bewcastle); coals very rare; generally some coloration of the shales and sandstones	500–1,500
	Basement Conglomerates (Upper Old Red Sandstone):—Local	—

SUPPLEMENT TO GEOLOGY.

Since the foregoing pages were written several new points have arisen in connexion with the Geology of Northumberland and Durham, which it will be necessary to incorporate with the "Outlines" in a new edition. Here it will be sufficient to indicate the nature of a few of these addenda.

First in importance is the publication by the Government Geological Survey of detailed and elaborate Memoirs on the Otterburn, Plashetts, and Kielder districts, and on the Cheviot Hills, by Messrs. Hugh Miller and C. T. Clough.[†] In the first named memoir the beds forming the lower portion of the Bernician series are very full and carefully described as they occur in the Redewater country, and the views of the author as to classification (see ante p. 146) are further developed. It should be noted that the large number of important faults which traverse and disturb that region renders a detailed description such as this of very special value. The lists of fossils from these lower beds are full of new information.

Mr. Clough's Plashetts Memoir is chiefly concerned also with lowest Carboniferous rocks, and from it is quoted the following very interesting and new list of Tuedian or, as he prefers to call them, Cement Stone fossils:—

Callymmatotheca bifida, L. and H.
Lepidodendron (Knorria condition).
Palæophycus, sp.
Pinnularia-like fossil.
Rhabdocarpus, sp.
Sphenopteris, sp.
S. (allied to S. elegans).

(†) Note: See the sheet memoirs of the Geological Survey.
108 S.E.—Otterburn and Elsdon, by Hugh Miller.
108 N.E.—Cheviot Hills, by C. T. Clough.
108 S.W.—Plashetts and Kielder, by C. T. Clough.

Chætetes.
Crinoid ossicles.
Serpula subannulata, Portl.
Spirorbis helicteres, Salt.
Cytherella, sp.
Crustacean fragment.
Leperditia Okeni, Münst.
L., sp.
Discina nitida, Phil.
Lingula mytiloides, Sby.
Rhynchonella pleurodon, Phil.
Spirifera distans, Sby.
Spiriferina laminosa, McCoy,
Aviculopecten knockonniensis, McCoy.
Axinus carbonarius, Portl.
Modiola, sp.
Myalina, sp.
Sanguinolites, sp.
Loxonema, sp.
Macrocheilus, sp.
Murchisonia quadricarinata, McCoy.
M. sp.
Archichthys Portlocki, Ag.
Ctenoptychius pectinatus, Ag.
Fish tooth.
Helodus, sp.
Palæoniscoid Fish.
Strepsodus, sp.

The above were determined by Messrs. E. T. Newton and G. Sharman, of the Jermyn Street Museum.

Descriptions of Tuff or Ash at Carter Fell, and of Basalt at the same locality, will be found at p. 16 of the Memoir.

In his Cheviot Memoir, Mr. Clough breaks almost new ground, and we are now for the first time made acquainted with the real extent, lie, and character of the igneous rocks that form those hills. He describes (*a*) Contemporaneous Carboniferous basalt in the immediate neighbourhood of the Outer Golden Pot; (*b*) a Mica trap dyke in the Silurian shales on the North side of Harden Edge, about one-third of a mile South-South East of the Ad Fines Camps; (*c*) the granite of Cheviot itself as occurring over a very much larger area than was before supposed, and as sending out strings into the surrounding porphyrite; (*d*) Elvan, including felstones and quartz-felsites; (*e*) the Porphyrite in dykes, over forty in number, and (*f*) Basaltic dykes at Bowhope Head, Blind Burn, and Harden Edge.

The Seaton Carew Boring:—This recent exploration by the Diamond Boring process has been the occasion of very considerably altering our views as to the termination of the coal-field to the South. Sandstones and shales, &c., probably Coal-measure (? Gannister series) age have by it been proved to exist beneath the Permian rocks at Seaton Carew. By it also the thickness of the Magnesian limestone has been shown to be greater than was imagined, and an important fault of great throw has been proved. A detailed section of the boring will be found in the Transactions of the North of England Institute of Mining and Mechanical Engineers, vol. xxxviii. (1889), p. 21.

The Team "Wash" at Dunston.—The excavations necessary for the foundations of a new mill by the Tyne at Dunston have recently revealed some very interesting sections of the Western portion of the superficial deposits which fill up the ancient valley that formerly united the Wear and the Tyne. The top of the Boulder Clay forms here a very irregular surface, covered with a great but variable thickness of finely laminated clay, sands, and gravels. In the laminated clay, at a considerable depth beneath the level of the river bottom, portions of a well-shaped canoe, hollowed out of a single log of wood, many varieties of timber, nuts, and a number of specimens of Anodon have been found.

CARBONIFEROUS AND PERMIAN VERTEBRATES.

Mr. R. Howse, of the Natural History Museum, has kindly favoured me with the following valuable notes :—

Coal-Measures.

List of Fishes and Amphibia (= Batrachia) of the Northumberland and Durham Coal-field. Most of these have been found in the Black Shale, above the Low Main Seam at Newsham Colliery, and are in the Atthey Collection, in the Museum the Natural History Society :—

1. Pisces.—Fishes.
Palæichthyes.
Ord. Ganoidei.

Fam. Palæoniscidæ.

Elonichthys (Pal.) Egertoni (Ag.)
„ „ Hancocki (Atthey.)
„ „ sp.
„ „ semistriatus, Traquair.
Acrolepis (Gyrolepis) Rankinii (Ag.)

Fam. Platysomidæ.

Platysomus parvulus, Ag.
„ rotundus, Hancock and Atthey.
„ Forsteri, „ „
Amphicentrum striatum, „ „

Fam. Cœlacanthidæ.

Cœlacanthus lepturus, Ag.

Fam. Rhizodontidæ.

Rhizodopsis sauroides, Huxley.
Archichthys sulcidens, Hancock and Atthey.
Strepsodus sauroides, Huxley.

Fam. Saurodipteridæ.

Magalichthys Hibberti, Ag.
„ coccolepis, Dr. J. Young.

Fam. Incert. sedis.

Acanthodopsis Egertoni, Hancock and Atthey.
„ Wardii, Egerton.
„ Ord. Chondropterygii.

A. Selachoidei—Sharks.

Fam. Cestraciontidæ.

Pleurodus Rankinii, Ag.

Fam. incert sedis.

Pœcilodus sp. (teeth).
Helodus simplex, Ag. (teeth).
Diplodus gibbosus, Ag. (teeth).
Pleuracanthus lævissimus, Ag. (spines).
Orthacanthus cylindricus, Ag. (spines).
Cladodus mirabilis, Ag. (teeth).
Ctenacanthus hybodoides, Egerton (spines).
Ctenoptychius pectinatus, Ag. (teeth).
Gyracanthus tuberculatus, Ag. (spines).

B. Batoidei—Rays.

Fam. Petalodontidæ.

Janassa linguæformis, Hancock and Atthey.

Ord. Dipnoi.

Ctenodus cristatus, Ag.
„ tuberculatus, Hancock and Atthey.
„ corrugatus, „ „
„ imbricatus, „ „
„ ellipticus, „ „
„ obliquus, „ „
„ elegans, „ „

2. Batrachia sive Amphibia.

A. Caudata—Tailed Batrachians.

Anthracosaurus Russelli, Hux.
Pteroplax cornuta, Hancock and Atthey.
Loxomma Allmanni, Hux.
Ophiderpeton nanum, Hancock and Atthey.
Urocordylus reticulatus, „ „
Batrachiderpeton lineatum, „ „

PERMIAN.

List of Fishes, Batrachia and Reptiles, found in the Marl-slate (*Kupferschiefer* Germ.), and Magnesian Limestone of Durham and Northumberland :—

1. Pisces—Fishes.

Palæichthyes.
Ord. Ganoidei.

Fam. Palæoniscidæ.

Palæoniscus Frieslebeni, Ag. *comptus* Ag.
„ elegans, Sedgwick.
„ longissimus, Ag.
„ macrophthalmus, Ag.
Acentrophorus (Pal.) glaphyrus (Ag.)
„ varians, Kirkby
„ altus, „ } Upper Magnesian Limestone.
„ Abbsii, „
Acrolepis Sedgwickii, Ag.
„ exsculptus, Germar.
„ Kirkbyi, Howse. Upper Magnesian Limestone.
Pygopterus mandibulatus, Ag.
? „ latus, Egerton

Fam. Platysomidæ.

Platysomus striatus, Ag.
Globulodus (Platy.) macrurus (Ag.)

Fam. Cœlacanthidæ.

Cœlacanthus granulatus, Ag.
„ caudalis, Egerton ?
Ord. Chondropterygii.

A. Selachoidei—Sharks.

Fam. Cestraciontidæ.

Woodnika striatula, Münster.

B. Batoidei—Rays.

Fam. Petalodontidæ.

Janassa bituminosa (Schloth.)

2. Batrachia.

A. Caudata—Tailed Batrachians.

Lepidotosaurus Duffii, Hancock and Howse.

3. Reptilia.

Ord. Rhynchocephala.

Proterosaurus Speneri, v. Meyer.
„ Huxleyi, Hancock, and Howse.

List of Fish Remains from the Calciferous Sandstone or Tuedian series and the Carboniferous Limestone (upper and lower series) of Northumberland and Durham.

CALCIFEROUS SANDSTONE OR TUEDIAN SERIES.

Rhizodus Hibberti (scales) Coldstream and Norham-on-Tweed
Ctenodus sp. (tooth) Norham (G. Tate)
Ctenoptychius pectinatus Ag. (teeth) Norham (G.T.)

CARBONIFEROUS LIMESTONE (LOWER SERIES).

Rhizodus Hibberti (tooth in coal) Scremerston
„ „ (scales) Redesdale Ironstone, Redesdale
Cochliodus contortus Ag. (tooth in drift) near Cambo (Sir W. C. Trevelyan)

Cochliodus magnus Ag. Lowick (McCoy)
Cochliodus (Xystrodus) striatus Ag. Lowick (McCoy)
Psephodus magnus Ag., Otterburn, Lowick (M.C.)
Psammodus rugosus Ag., var. porosus, Lowick (M.C.)
„ cornutus Ag., Lowick (M.C.)
Pœcilodus Jonesii Ag., Lowick (M.C.)
Oracanthus minor (spine), Bellingham, in Ironstone band (R.H.)
Leptacanthus Jenkinsoni, McCoy, Lowick (M.C.)
? „ junceus (spine), Redesdale, in Ironstone nodule (R.H.)
Gyracanthus tuberculatus Ag. (spine), Scremerston, in coal; Redesdale, in Ironstone
Cladodus ? mirabilis Ag. (tooth), Redesdale, in Ironstone

CARBONIFEROUS LIMESTONE (UPPER SERIES.)

Petalodus acuminatus Ag., Whorlton-on-Tees (Sir Rod. Murchison), Corbridge (W. Dinning.)
Chomatodus (Helodus) cinctus Ag., Belsay (M.C.)
* Gyracanthus tuberculatus Ag., Stanhope, in Weardale.
Clarodus ? mirabilis Ag., Corbridge-on-Tyne (W.D.)

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* The only Fish Remain recorded from Durham (Co.) up to the present time is the spine of Gyr. tuberculatus.

NATURAL HISTORY.

MAMMALIA.

There is nothing sufficiently remarkable about the land mammals of Northumberland and Durham to necessitate the insertion here of a formal list. Most of the ordinary British forms occur in these counties, and with the exception of the Chillingham cattle, of which an excellent account will be found in the notes drawn up for the Chillingham excursion of the Association, none can claim to be in any way peculiar to the district.

Some quadrupeds, recently fairly common, are now extinct in this region, or nearly so, such as the Wild Cat and the Badger. The Otter is still found along most of the rivers, but in very reduced numbers.

Both Red and Fallow deer are kept in a few large parks, but they can scarcely be regarded as native to the district in the sense of being the actual decendants of the wild deer once common enough in it. They are rather a re-introduction under somewhat artificial conditions, by man, of really extinct animals.

The marine mammalia are mostly of the visitant kind. It is questionable whether any of those seen from time to time off the coast, except perhaps the Porpoise, can with any truth be looked upon as denizens, Whales are not unfrequently stranded at various points of the coast line, as is evidenced by the large number of Whales' jaw bones used as gate-posts in farm yards and elsewhere throughout the two counties. A complete list of these would be interesting, but the materials are not at hand for its compilation. Specimens of Rudolphi's Rorqual (Balœnoptera borealis) from Newbiggin-by-the-Sea, and of a small Bottle-nose Whale from Tynemouth, are preserved in the East Corridor of the Natural History Museum.

Seals are not rare at the Farne Islands, and have occasionally been seen at several points of the coast, but they come from higher latitudes.

REPTILIA AND AMPHIBIA.

The viper (adder), the blind worm, the frog, toad, newt, with, as I am informed, the common lizard, which I have never myself seen North of the Tees, make up the list for the two North-Eastern Counties. The common snake of the South of England (Coluber natrix), is unknown. The red viper (Coluber chersea) is, however, recorded as having been found.

FISHES.

It is to be regretted that no good list exists of the fishes met with off this coast. Brief notices of rarities are scattered through the "Tyneside and Berwickshire Transactions," and in other publications, and many of the most interesting have, fortunately, been preserved in the Natural History Museum, but no complete record is extant.

A fine specimen of the ribbon fish (Gymnetrus Banksii), was caught in 1849 at Cullercoats, and is now in the museum. It has been described and figured by Dr. D. Embleton, in Vol. 1 of the "Transactions of the Field Club." Another specimen was caught not long after off the mouth of the Tees at Redcar. The black fish (Centroplophus pompilius), short sun fish (Orthragoriscus mola), and the porbeagle shark (Lamna Cornubica) are, amongst others, rare visitants. The sturgeon is not rare.

The common food fishes brought in by the fishing boats are the herring, haddock, whiting, cod, ling, codling, halibut, lemon sole, devil fish, lump fish, etc., with salmon, salmon trout, and trout from the sea and rivers.

BIRDS.

FROM MR. JOHN HANCOCK'S "CATALOGUE OF THE BIRDS OF NORTHUMBERLAND AND DURHAM" (VOL. VI. OF THE NATURAL HISTORY TRANSACTIONS OF NORTHUMBERLAND AND DURHAM, 1874), WITH A FEW ADDITIONS FROM OTHER SOURCES.

In the following list the capital letters after each bird's name indicate whether it is a *Resident* (R), a *Spring and Autumn migrant* (S.A.V.), an *Autumn and Winter visitant* (A.W.V.), or a *casual visitant* (C.V.) Mr. Hancock defines these terms thus :

" A *resident* is a species which remains in the district throughout the year, whether it breeds in it or not. If a few individuals only remain throughout the year, though the greater number migrate, the species is considered a resident. The Sparrow, Common Gull, and Crossbill are examples.

A *Spring and Autumn migrant* arrives in spring, breeds in the district, and departs in the autumn. Of this the swallow is a type.

An Autumn or Winter visitant arrives in autumn or winter, and departs shortly or sojourns till spring. Examples are the Green Sandpiper and the Fieldfare.

A casual visitant is one that does not regularly visit the district, but whose appearance is uncertain. Under this term are included not only the species which visit the district at irregular periods, of which the Hoopoe and rose-coloured Pastor are examples, but those likewise that are mere strays, such as Pallas's Sand Grouse and White's Thrush."

Aquila fulva, Linn., C. V.
*A. clanga or nœvia, C. V.

Haliætus albicilla, Linn., rare C. V.

Pandion haliætus, Linn., not unfrequent C. V.

Buteo vulgaris, Linn., C. V.

Archibuteo lagopus, Brunn., rare C. V.

Pernis apivorus, Linn., S. A. V.

Milvus regalis, Brisson, rare C. V.
M. ater, Gmel., very rare C. V.

Hierofalco Islandicus, Breton., rare C. V.

Falco peregrinus, Gmel., R.
F. subbuteo, Linn., rare C. V.
F. vespertinus, Linn., rare C. V.
F. æsalon, Gmel., R.
F. tinnunculus, Linn., R.

Astur palumbarius, rare C. V.

Accipiter nisus, Linn., common R.

Circus æruginosus, Linn., R. (?)
C. cyaneus, Linn., C. V.
C. cinereus, Mont., R. (?)

Surnia nyctea, Linn., rare V.

Nyctale Tengmalmi, Gmel., rare C. V.

Syrnium aluco, Linn., common R.

Strix flammea, Linn., common R.

Otus brachyotus, Forster, R.
O. vulgaris, Flem., R.

Bubo maximus, Flem., rare V.

Picus major, Linn., R.
P. minor Linn., rare C. V.

Gecinus viridis, Linn., R.

Yunx torquila, Linn, S. A. V.

Cuculus canorus, Linn., S. A. V.

Oxylophus glandarius, Linn., very rare V.

Coracias garrula, Linn., rare C. V.

Merops Phillipensis, Linn., very rare C. V.

Alcedo ispida, Linn., R.

Sitta Europæa, Linn., rare C. V.

Certhia familiaris, Linn., R.

Upupa epops, Linn., C. V.

Corvus corax, Linn., R.
C. corone, Linn., R.

C. cornix, Linn., common W. V.
C. frugilegus, Linn., R.
C. monedula, Linn., R.

Coracia gracula, Linn., R.

Nucifraga caryocatactes, Linn., rare C. V.

Pica caudata, Linn., R.

Garrulus glandarius, Linn., R.

Lanius excubitor, Linn., rare W. V.
L. Rufus, Briss., rare C. V.
L. collurio, Linn., rare C. V.

Sturnus vulgaris, Linn., R.

Pastor roseus, Linn., rare C. V.

Passer domesticus, Briss., R.
P. montanus, Briss., R.
Pyrrhula vulgaris, Temminck, R.

Corythus enucleator, Linn., C. V.

Loxia curvirostra, Linn., R.
L. bifasciata, Brehm., C. V.

Coccothraustes vulgaris, Vieillot, rare C. V.

Ligurinus chloris, Linn., R.

Fringilla cœlebs, Linn., R.
F. montifringilla, Linn., W. V.

Carduelis elegans, Stephens, C. V.

Chrysomitris spinus, Linn., R.

Cannabina linota, Gmel., R.
C. flavirostris, Linn., R.

Linaria borealis, Vieillot, W. V.
L. canescens, Gould, C. V.
L. rufescens, Vieil., R.

Miliaria Europœa, Swains, R.

Emberiza citrinella, Linn., R.

Cynchramus schoeniclus, Linn., R.

Plectrophanes nivalis, Linn., W. V.
P. lapponicus, Linn., C. V.

Alauda arvensis, Linn., R.
A. arborea, Linn., C. V.

Otocoris alpestris, Linn., C. V.

Corydalla Richardi, Vieil., C. V.

Anthus arboreus, Briss., S. A. V.
A. pratensis, Linn., R.
A. obscurus, Penn., R.

Budytes flava, Linn., S. A. V.
B. Rayi, Bonap., S. A. V.

Motacilla Yarrellii, Gould., R.
M. sulphurea, Bechs., R.

Hydrobata cinclus, Linn , R.

Oriolus galbula, Linn., C. V.

Turdus merula, Linn., R.
T. torquatus, Linn., S. A. V.
T. pilaris, Linn., W. V.
T. viscivorus, Linn., R.
T. aureus, Holl., C. V.
T. iliacus, Linn., W. V.
T. musicus, Linn,, R.

Rubecula familiaris, Blyth, R.

Cyanecula Suecica, Linn., C. V.

Ruticilla Phœnicura, Linn., S. A. V.
R. tithys, Scopoli, S. A. V. (?)

Saxicola Œnanthe, (Linn.), S. A. V.

Pratincola rubetra, Linn., S. A. V.
P. rubicola, Linn., R.

Prunella modularis, Linn., R.

Sylvia atricapilla, Linn., S. A. V.
S. hortensis, Gmel., S. A. V.

Curruca garrula, Briss, S. A. V.
C. cinerea, Briss., S. A. V.

Calamoherpe turdoides, Meyer, C. V.

Locustella nævia, Briss., S. A. V.

Calamodyta phragmitis, Bechs, S. A. V.

Troglodytes parvulus, Koch., R.

Phyllopneuste trochilus, Linn., S. A. V.
P. rufa, Briss., S. A. V.
P. sibilatrix, Bechs., S. A. V.

Reguloides superciliosus, Gmel., C. V.

Regulus cristatus, Charl., R.

Parus major, Linn., R.
P. ater, Linn., R.
P. cæruleus, Linn., R.

Pæcile palustris, Linn., R.

Orites caudatus, Linn., R.

Ampelis garrulus Linn., C. V.

Muscicapa nigra, Briss., S. A. V.

Butalis grisola, Linn., S. A. V.

Hirundo rustica, Linn., S. A. V.

Chelidon urbica, Linn., S. A. V.
C. riparia, Linn., S. A. V.

Cypselus apus, Linn., S. A. V.
*C. melba C. V.

Caprimulgus Europœus, Linn., S. A. V.
C. ruficollis, Temminck, C. V.

Columba palumbus, Linn., R.
C. Ænas, Linn., R.
C. livia, Briss, R.

Turtur auritus, Ray, C. V.

Syrrhaptes paradoxus, Pallas, C. V

Lapopus Scoticus, Briss., R.

Tetrao tetrix, Linn., R.

Starna cineria, Charl., R.

Coturnix communis, Bonnaterre, S. A. V.
C. Virginianus, Linn., introduced species.

Phasianus Colchicus, Linn., R.

Otis tarda, Linn., C. V.
O. tetrax, Linn., C. V.

Œdicnemus crepitans, Temm., C. V.

Cursorius Gallicus, Gmel., C. V.

Pluvialis apricarius, Linn., R.
P. varius, Briss., W. V.

Morinellus Sibericus, Lepechin, S. A. V.

Charadrius hiaticula, Linn., R.

Vanellus cristatus, Meyer and Wolf, R.

Hœmatopus ostralegus, Linn., R.

Strepsilas interpres, Linn., A. W. V.

Numenius arquata, Linn., R.
N. phæopus, Linn., A. W. V.

Limosa ægocephala, Linn., C. V.
L. rufa, Briss., A. W. V.

Scolopax rusticula, Linn., R.

Gallinago major, Gmel., A. W. V.
G. scolopacinus, Bonap., R.
G. gallinula, Linn., A. W. V.

Calidris arenaria, Linn., A. W. V.

Tringa canutus, Linn., A. W. V.
T. maritima, A. W. V.

Pelidna subarquata, Güldenst, A. V.
P. cinclus, Linn., R.
P. maculata, Vieil., C. V.
P. minuta, Leisler, A. V.
P. Temminckii, Leisler, A. V.

Machetes pugnax, Linn., S. A. V.

Totanus griseus, Briss., A. V.
T. fuscus, Linn., A. W. V.
T. calidris, Linn., R.
T. glareola, Linn., S. A. V.
T. ochropus, Linn., A. V.

Actitis hypoleucos, Linn., S. A. V.

Phalaropus fulicarius, Linn., C. V.

Lobipes hyperboreus, Linn., C. V.

Recurvirostra avocetta, Linn., C. V.

Rallus aquaticus, Linn., R.

Crex pratensis, Bechs., S. A. V.

Porzana maruetta, Briss., R.

Gallinula chloropus, Linn., R.

Porphyris cæsius, Barrère, C. V.

Fulica atra, Linn., R.

Ardea cinerea, Linn., R.

Ardeola minuta, Linn., C. V.

Botaurus stellaris, Linn., C. V.

Nycticorax Europæus, Stephens, C. V.

Ciconia alba, Willoughby, C. V.
C. Nigra, Gesner, C. V.

Platalea lencorodia, Linn., C. V.

Falcinellus igneus, Gmel., C. V.

Sula Bassana, Briss., R.

Phalacrocorax carbo, Linn., R.
P. cristatus, Fab., R.

Procellaria glacialis, Linn., C. V.

Puffinus Anglorum, Gmel, C. V.
P. fuliginosus, Strick., C. V.

Thalassidroma pelagica, Linn., C. V.
T. leucorrhoa, Vieil., C. V.

Stercorarius catarractes, Linn., A. W. V.
S. pomarinus, Temm., W. V.
S. parasiticus, Linn., A. W. V.
S. longicaudus, Briss., C. V.

Pagophila eburnea, Gmel., C. V.

Larus glaucus, Brünn., A. W. V.
L. leucopterus, Faber., C. V.
L. marinus, Linn., R.
L. fuscus, Linn., R.
L. argentatus, Brünn., R.
L. canus, Linn., R.
L. tridactylus, Linn., R.

L. ridibundus, Linn., R.
L. minutus, Pallas, A. W. V.

*Xema Sabinii, C. V.

Sterna Cantiaca, Gmel., S. A. V.
S. hirundo, Linn., S. A. V.
S. paradisea, Brünn., S. A. V.
S. Dougallii, Mont., S. A. V.
S. minuta, Linn., S. A. V.

Hydrochelidon fissipes, Linn., C. V.
H. nigra, Linn., C. V.

Cygnus ferus, Ray, W. V.
C. minor, Pallas, W. V.

Anser cinereus, Meyer, C. V.
*A. erythropus, C. V.
A. sylvestris, Briss., A. W. V.
A. brachyrhynchus, Baillon, A. W. V.
A. albifrons, Bechs,, A. W. V.

Bernicla leucopsis, Bechs., A. W. V.
B. brenta, Briss., A. W. V.
B. ruficollis, Pallis, C. V.
B. canadensis, Willoughby, C. V.

Chenalopex Ægyptiaca, C. V. (?)

Tadorua Belonii, Ray, R.

Spatula clypeata, Linn., S. A. V.

Anas boschas. Linn., R.

Chaulelasmus strepera, Linn., C. V.

Mareca Penelope, Linn., A. W. V.

Dafita acuta, Linn., R.

Querquedula circia, Linn., C. V.
Q. crecca, Linn., R.

Branta rufina, Pallas, C. V.

Fuligula cristata, Linn., R.
*F. histrionica, C. V.
F. marila, Linn., W. V.
F. ferina, Linn., W. V.
F. nyroca, Guldenst., C. V.

Clangula glaucion, Linn., W. V.

Harelda glacialis, Linn., W. V.

Somateria mollissima, Linn., R.
S. spectabilis, Linn , C. V.

Oidemia nigra, Linn., W. V.
O. fusca, Linn., W. V.

Colymbus glacialis, Linn., W. V.
C. arcticus, Linn., W. V.
C. septentrionalis, Linn., W. V.

Uria troile, Linn., R.
U. grylle, Linn., W. V.

Mergulus alle, Linn., W. V.

Fratercula arctica, Linn., R.

Alca torda, Linn., R.
A. impennis, Linn., Extinct.

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*The names marked with an asterisk have been kindly communicated by Mr. A. C. Chapman, who also informs me that a specimen of Hypolais icterina was killed near Newcastle-upon-Tyne in June, 1889.

MOLLUSCA.

FROM THE LATE MR. JOSHUA ALDER'S "CATALOGUE OF THE MOLLUSCA OF NORTHUMBERLAND AND DURHAM" (VOL. I. OF THE TRANSACTIONS OF THE TYNESIDE NATURALISTS' FIELD CLUB, 1850), WITH A FEW ADDITIONS FROM OTHER SOURCES.

Eledone ventricosa, Grant., not uncommon.

Sepiola Rondeletii, Leach, rather rare.

Loligo vulgaris, Lam., not uncommon.
L. Sagitta, Lam., rather rare.
L. Media, Linn., very rare.

Sepia officinalis, Linn., not common.

Doris tuberculata, Cuv., common.
D. Johnstoni, Ald. and Hanc., rather rare.
D. repanda, Ald. and Hanc., not rare, local.
D. mera, Ald. and Hanc., very rare.
D. aspera, Ald. and Hanc., common.
D. bilamellata, Linn., common.
D. depressa, Ald. and Hanc., very rare.
D. sparsa, Ald. and Hanc., very rare.
D. stellata. Gmel., not uncommon.
D. similis, Ald. and Hanc.

Goniodoris nodosa, Mont., common.

Triopa claviger, Müll., rare.

Polycera quadrilineata, Müll., common.
P. ocellata, Ald. and Hanc., not rare.
P. Lessonii, d'Orb., common.

Ancula cristata, Alder, common.

Idalia aspersa, Ald. and Hanc., very rare.
I. elegans, Lenck., (?) very rare.

Tritonia Hombergii, Cuv., rather rare.
T. plebeia, Johnst., common.

Dendronotus arborescens, Müll., not uncommon.

Doto fragilis, Forbes, not rare.
D. coronata, Gmel., rather rare.

Eolis papillosa, Linn., not uncommon.
E. rosea, Ald. and Hanc., rare.
E. obtusalis, Ald. and Hanc., rare.
E. Peachii, Ald. and Hanc., very rare.
E. coronata, Forbes, very common.
E. curta, Ald. and Hanc., very rare.
E. rufibranchialis, Johnst., rather rare.
E. pellucida, Ald. and Hanc., very rare.
E. gracilis, Ald. and Hanc., rare.
E. angulata, Ald. and Hanc, very rare.
E. nana, Ald. and Hanc., occasionally found.
E. concinna, Ald. and Hanc., very rare.
E. olivacea, Ald. and Hanc., frequent.
E. aurantiaca, Ald. and Hanc., rather rare.
E. cingulata, Ald. and Hanc., very rare.
E. vittata, Ald. and Hanc., very rare.
E. northumbrica, Ald. and Hanc., very rare.
E. picta, Ald. and Hanc., frequent.
E. tricolor, Forbes, very rare.
E. amethystina, Ald. and Hanc., very rare.
E. despecta, Johnst., rare.

Limapontia nigra, Johnst., plentiful.

Pleurobranchus plumula, Mont., rare.

Aplysia punctata, Cuv., not uncommon.

Bullæa catena, Mont., frequent.
B. pruinosa, Clark, very rare.
B. strigella, Lovén, very rare.
B. punctata, Adams, rare.
B. pectinata, Dillw., not uncommon.

B. quadrata, S. Wood, rare. This is interesting as being a crag fossil species.
B. pruinosa, Clark, very rare.

Bulla Cranchii, Leach, rare.
B. umbilicata, Mont., very rare.
B. cylindracea, Penn., frequent.
B. truncata, Adams, frequent.
B. obtusa, Mont., rather rare.

Amphisphyra hyalina, Lovén, not rare.

Actæon tornatilis, Linn., rather rare.

Arion ater, Linn., very common.
A. flavus, Müll., very rare.
A. hortensis, Fér., common.

Limax maximus, Linn., frequent.
L. arborum, Bouchard, not common.
L. flavus, Linn., not common.
L. Sowerbii, Fér., rare.
L. tenellus, Müll., very rare.
L. agrestis, Linn., very common.
L. brunneus, Drap., frequent.

Vitrina pellucida, Müll., frequent.

Succinea putris, Linn., common.

Helix aspersa, Müll., very common.
H. arbustorum, Linn., frequent.
H. nemoralis, Linn., common.
H. hortensis, Müll., frequent.
H. cantiana, Mont., not common.
H. rufescens, Penn., not uncommon on magnesian limestone.
H. hispida, Müll., common.
H. granulata, Alder, common locally.
H. fusca, Mont., frequent.
H. excavata, Alder, rare.
H. lucida, Drap., rare.

H. radiatula, Alder, not uncommon.
H. nitidula, Drap., common.
H. alliaria, Miller, common.
H. cellaria, Müll., common.
H. pura, Alder, not uncommon.
H. crystallina, Müll., common.
H. fulva, Müll., frequent.
H. lamellata, Jeff., not common.
H. aculeata, Müll., rare.
H. pulchella, Müll., local, generally on limestone.
H. pygmæa, Drap., not uncommon.
H. rupestris, Drap., local, apparently on limestone only.
H. rotundata, Müll., common.
H. caperata, Mont., common on limestone, rare inland.
H. virgata, Da Costa, common locally, always on limestone.
H. ericetorum, Linn., not uncommon, chiefly on limestone.

Bulimus obscurus, Müll., frequent, chiefly on limestone.

*Z*ua lubrica, Müll., common.

Achatina acicula, Müll., rare.

Azeca tridens, Mont., locally plentiful.

Clausilia laminata, Mont., frequent.
C. dubia, Drap., not common, restricted to limestone (?).
C. rugosa, Drap., not uncommon.

Balæa perversa, Linn., not common.

Pupa marginata, Drap., frequent.
P. umbilicata, Drap., common.
P. anglica, Fér., rather rare.
Vertigo cylindrica, Fér., very rare.
V. edentula, Drap., frequent.
V. pygmæa, Drap., not rare.
V. alpestris, Alder, very rare.
V. palustris, Jeff., rare.
V. substriata, Jeff., rather rare.
V. pusilla, Müll, rather rare.

Acme lineata, Drap., rare.

Carychium minimum, Müll., common.

Conovulus denticulatus, Mont., rare.
C. bidentatus, Mont., rare.

Limnæa stagnalis, Linn., not common.
L. palustris, Linn., not uncommon.
L. truncatula, Müll., common.
L. glabra, Müll., not uncommon.
L. peregra, Müll., very common.
L. auricularia, Linn., not common.

Physa fontinalis, Linn., not common.
P. hypnorum, Linn., frequent.

Planorbis corneus, Linn., not common.
P. albus, Müll., frequent.
P. lævis, Alder, not common.
P. nautileus, Linn., frequent.
P. carinatus, Müll., rare.
P. umbilicatus, Müll., not common.
P. spirorbis, Linn., common.
P. nitidus, Müll., rather rare.
P. contortus, Linn., not common.

Ancylus fluviatilis, Müll., common.
A. lacustris, Müll., not common.

Bithinia tentaculata, Linn., not common.

Valvata piscinalis, Müll., rather rare.
V. cristata, Müll., rare.

Stylifer Turtoni, Brod., rare.

Eulima distorta, Desh., very rare.
E. lineata, Sow., rather rare.
E. nitida, Alder, very rare.
E. gracilis, Desh., very rare.

Scalaria communis, Lam., very rare.

S. Turtonis, Turt., very rare.
S. Trevelyana, Johnst., rare.

Chemnitzia fulvocincta, Thomp., very rare.
C. indistincta, Mont. (?), rather rare.
C. unica, Mont., rare.
C. nitidissima, Mont., very rare.
C. acicula, Phil. (?), very rare.
C. Macandrei, Forbes., very rare.

Odostomia unidentata, Mont., rather rare.
O. turrita, Hanley, rare.
O. albella, Lovén, rare.
O. conspicua, Alder, very rare, first dredged off the Durham Coast.
O. pallida, Mont., rather rare.
O. nitida, Alder, very rare.
O. insculpta, Mont., rare.
O. spiralis, Mont., frequent.
O. interstincta, Mont., rather rare.
O. obliqua, Alder, rare.
O. acuta, Jeff., very rare.

Rissoa costata, Adams, frequent
R. vitrea, Mont., very rare.
R. striata, Adams, frequent.
R. parva, Da Costa, common.
R. inconspicua, Alder, rather rare.
R. cimicioides, Forbes, very rare.
R. punctura, Mont., frequent.
R. semistriata, Mont., not uncommon.
R. interrupta, Adams, abundant.
R. cingillus, Mont., rare.
R. unifasciata, Mont., rare.
R. ulvæ, Penn., common.
R. ventrosa, Mont., very rare.
R. (?) diaphana, Alder, rare.

Littorina littorea, Linn., common.
L. rudis, Maton, common.

L. rudissima, Bean, abundant.
L. neglecta, Bean, not rare.
L. petræa, Mont., frequent.
L. retusa, Lam., common.

Lacuna pallidula, Da Costa, not uncommon.
L. puteola, Turt., rather rare.
L. vincta, Mont., common.
L. labiosa, Lovén (?), very rare.
L. crassior, Mont., rare.

Skenea planorbis, Fab., common.
S. divisa, Flem., rare.

Trochus magus, Linn., very rare.
T. cinerarius, Linn., common.
T. tumidus, Mont., frequent.
T. millegranus, Phil., rare.
T. zizyphinus, Linn., not uncommon.

Margarita helicina, Fab., common.

Turritella terebra, Linn., not uncommon.

Aporrhais pes-pelicani, Linn., not common.

Pleurotoma teres, Forbes, very rare.
P. nebula, Mont., very rare.
P. brachystoma, Phil., very rare.
P. costata, Mont., not rare.
P. Boothii, Smith, very rare.
P. linearis, Mont., frequent.
P. rufa, Mont., not rare.
P. Trevelyana, Turt., rare.

Fusus turricula, Mont., not uncommon.
F. clathratus, Linn., not rare.
F. Barvicensis, Johnst., rare.
F. gracilis, Da Costa, frequent.
F. propinquus, Alder, rare. First found off this coast.
F. Islandicus, Chemn., very rare.
F. Turtoni, Bean, rare.

F. Norvegicus, Chemn., rare.
F. antiquus, Linn., common.
F. (?) minimus, Mont., rare.

Trichotropis borealis, Brod. and Sow., rare.

Purpura lapillus, Linn., common.

Buccinum undatum, Linn., common
B. avum, Turt., very rare.

Nassa reticulata, Linn., rare.
N. incrassata, Müll, abundant.

Trivium europæum, Mont., common.

Natica catena, Da Costa, not common
N. Alderi, Forbes, common.
N. intricata, Don., rare.
N. Montagui, Forbes, rather rare.
N. Groenlandica, Beck, rare.
N. helicoides, Johns., very rare.

Velutina lævigata, Penn., frequent.
V. plicatilis, Müll, rare.
V. (?) otis, Turt., rare.

Lamellaria perspicua, Linn., rare.
L. tentaculata, Mont., rather rare.

Emarginula fissura, Linn., rare.

Puncturella noachina, Linn., very rare.

Capulus hungaricus, Linn., rather rare.

Patella vulgata, Linn., common.
P. athletica, Bean, rather rare.
P. pellucida, Linn., common.
P. lœvis, Penn., common.

Lottia virginea, Müll, frequent.

Chiton fascicularis, Linn., not uncommon.
C. Hanleyi, Bean, rare.

C. marginatus, Penn., common.
C. cinereus, Linn., frequent.
C. ruber, Linn., frequent.
C. lævigatus, Flem., very rare.
C. lævis, Mont., rare.

Dentalium entalis, Linn., not common.

Cæcum trachea, Mont., rare.
C. glabrum, Mont., rare.

Terebratula psittacea, Gmel., very rare.

Anomia ephippium, Linn., not common.
A. squamula, Linn., frequent.
A. patelliformis, Linn., frequent.
A. aculeata, Müll., frequent.
A. cylindrica, Gmel., not uncommon.

Ostrea edulis, Linn., not common.

Pecten maximus, Linn., rather rare.
P. opercularis, Linn., frequent.
P. striatus, Müll., very rare.
P. tigrinus, Müll., frequent.
P. similis, Laskey, rare.
P. varius, Linn., not common.
P. distortus, Da Costa, frequent.

Lima Loscombi, Sow., rare.
L. subauriculata, Mont., very rare.

Pectunculus pilosus, Linn., rare.

Arca cardissa, Lam., frequent.

Leda caudata, Don., frequent.

Nucula nucleus, Linn., not uncommon.
N. nitida, Sow., rather rare.
N. tenuis, Mont., frequent.

Mytilus edulis, Linn., very common.

Modiola vulgaris, Flem., common.

M. phaseolina, Phil., rare.
M. nigra, Gray, rare.
M. descrepans, Mont., common.
M. marmorata, Forbes, common.

Crenella decussata, Mont., rare.

Anodon anatinus,, Linn., frequent.

Unio pictorum, Linn., rare.
U. margaritifera, Linn., common.

Cardium echinatum, Linn., frequent.
C. edule, Linn., abundant.
C. fasciatum, Mont., not uncommon.
C. nodosum, Mont., rare.
C. norvegicum, Spengler, not rare.

Artemis exoleta, Linn., frequent.
A. cincta, Pult., not uncommon
A. undata, not common.

Venus verrucosa, Linn, very rare
V. casina, Mont., rather rare.
V. fasciata, Da Costa, rather rare.
V. gallina, Linn., common.
V. ovata, Penn., rather rare.
Pullastra aurea, Gmel., rare.
P. virginea, Linn., not common.
P. decussata, Linn., not common.
P. vulgaris, Sow., not uncommon.
P. perforans, Mont., common.
Cyprina Islandica, Linn., common.

Astarte Damnoniæ, Mont., not uncommon.
A. scotica, Maton and Rackett, rather rare.
A. elliptica, Brown, rare.
A. compressa, Mont., frequent.
A. triangularis, Mont., rare.

Donax anatina, Lam., common.

Tellina tenuis, Da Costa, common.

T. fabula, Gmel., not uncommon.
T. donacina, Linn., rare.
T. pygmæa, Lovén, not common.
T. solidula, Pult., not uncommon.
T. crassa, Penn., not uncommon.

Psammobia Feroensis, Gmel., frequent.
P. vespertina, Gmel., rare.
P. tellinella, Lam., rather rare.

Syndosmya alba., Wood, common.
S. intermedia, Thomp., very rare.
S. prismatica, Mont., rare.
S. tenuis, Mont., rare.

Scrobicularia plana, Da Costa, not rare.

Mactra solida, Linn., not common.
M. elliptica, Brown, not uncommon.
M. subtruncata, Da Costa, frequent.
M. stultorum, Linn., common.

Lucina borealis, Linn., common.

Cryptodon flexuosus, Mont., rare.

Cyclas corneus, Linn., common.
C. calyculata, Drap., not common.

Pisidium obtusale, Pfeiff., rare.
P. pusillum, Turt., frequent.
P. nitidum, Jenyns, rare.
P. pulchellum, Jenyns, not uncommon.
P. cinereum, Alder, common.
P. amnicum, Müll., rather rare.

Lepton convexum, Alder, very rare; first found at Cullercoats.

Kellia suborbicularis, Mont., not rare.
K. rubra, Mont., not common.

Turtonia minuta, Fab., common.

Montacuta bidentata, Mont., not uncommon.
M. substriata, Mont., abundant.
M. ferruginosa, Mont., rare.

Neæra cuspidata, Olivi., very rare.

Corbula gibba, Olivi., not rare.

Thracia convexa, Wood, rare.
T. phaseolina, Lam., not uncommon.
T. villosiuscula, Maeg., rather rare.

Anatina prætenuis, Petiver, rare.
A. distorta, Mont., rare.

Lyonsia Norvegica, Chemn., rare.

Lutraria elliptica, Lam., abundant in places.

Mya truncata, Linn., not uncommon.
M. uddevalensis, Forbes; supposed by the late Prof. King to be fossil from a Pleistocene stratum beneath the sea.
M. arenaria, Linn., not rare.

Solen siliqua, Linn., common.
S. ensis, Linn., frequent.
S. pellucidus, Penn., rare.

Saxicava rugosa, Penn., frequent

Pholas crispata, Linn., common.
P. candida, Linn., frequent.

Xylophaga dorsalis, Turt., rare.

Teredo Norvegica, Spengler, not rare, but scarcely native.

Pelonaia corrugata, Forb. and Goods., not rare.

Cynthia tuberosa, Macg., (?) not uncommon.
C. glacialis, Sars, very rare.
C. grossularia, V. Bened., rather scarce.
C. coriacea, Ald. and Hanc., not common.
C. ampulla, Brug., not uncommon.
C. rustica, Linn., common.

Molgula arenosa, Ald. and Hanc, not uncommon.
M. siphonata, Ald., rare.

Ascidia intestinalis, Linn., not uncommon.
A. sordida, Ald. and Hanc., common.
A. virginea, Müll., rare.
A. vitrea, Van Beneden (?), not common.
A. albida, Ald. and Hanc., not uncommon.
A. depressa, Ald. and Hanc., common.
A. elliptica, Ald. and Hanc., not common.
A. pellucida, Ald. and Hanc., rare.

Clavellina lepadiformis, Müll., rare.

Aplidium ficus, Linn (?), rare.
A. fallax, Johnst., rare.

Sidnyum turbinatum, Savigny (?), not rare.

Polyclinum aurantium, M. Edw. (?), rather rare.

Leptoclinum punctatum, Forbes, not uncommon.

Botryllus Schlosseri, Pallas, common.
B. virescens, Ald. and Hanc., not uncommon.
B. polycyclus, Sav. (?), not rare.
B. castaneus, Ald. and Hanc., rare.

Botrylloides Leachii, Sav. (?), common.
B. radiata, Ald. and Hanc., frequent.
B. albicans, M. Edw., not common.
B. ramulosa, Ald. and Hanc., rare.

NOTES ON THE MOLLUSCA OF NORTHUMBERLAND AND DURHAM.

Of 150 marine Mollusca enumerated by Dr. Philippi as common to Britain and Sicily, not more than a third of them reach our north-eastern shores, and it is curious that none of the latter are really southern forms, they being nearly all of a cosmopolite character, and equally common to the north of Europe. About half the species of Alder's catalogue are Scandinavian, whilst scarcely a fifth are Mediterranean.

The species most characteristic of our locality are :—

Bullæa pectinata.
B. quadrata.
B. Cranchii.
Amphisphyra hyalina.
Fusus Norvegicus.
F. Turtoni.
F. Islandicus.
F. Barvicensis.
Velutina plicatilis.
Scalaria Trevelyana.
Natica Montagui.
N. helicoides.
N. Groenlandica.
Margarita helicina.
Nucula tenuis.
Modiola nigra.
Astarte compressa.
Neæra cuspidata.
Panopæa Norvegica.

Fusus antiquus and F. gracilis, Cyprina Islandica, and Modiola are large and common, but though rare off the south coast of England, they are common elsewhere, and are therefore scarcely characteristic.

Lottia—(Acmæa) testudinalis: In 1850 (the date of Alder's catalogue) was conspicuous for its absence, though so common on the West of Scotland, Ireland, and Wales. Since that date it has become plentiful on the North-East Coast.

Other northern species not uncommon on the western shores of Scotland are also absent here, such as—

Lima hyans.
Terebratula caput-serpentis.
Crania anomala.
Pecten niveus.
P. nebulosus.
Leda pygmæa.
Margarita carnea.

The following south of England species do not occur with us :—

Bulla hydatis.
Eulima polita.
Scalaria clathratula.
Truncatella montagui.
Ianthina fragilis.
Rissoa crenulata
R. striatula.
Phasianella pullus.
Trochus umbilicatus.
T. striatus.
Ovula patula.
Fissurella reticulata.
Calyptræa chinensis.
Modiola Gibbsii
Arca lactea.
Cardium aculeatum.
C. exiguum.
Cytherea chione.
Tellina depressa.
Petricola irus.

T. crassus.
Pleurotoma gracilis.
P. septangularis.
P. purpurea.
Fusus muricatus.
Erato lævis.
Pandora obtusa.
Galeomma Turtoni.
Gastrochæna pholadia.
Pholas parva.
P. papyracea.
P. dactylus.

These may all be considered southern forms which have not reached our limits, but some of them attain a much higher latitude on the western side of Great Britain.

CRUSTACEA.

It is not possible yet to give complete lists of the Crustacea of Northumberland and Durham, but a very valuable report on the forms dredged during the exploration referred to in the Introduction, by Canon Norman, D.C.L., will be found in Vol. V. of the Tyneside Transactions. 101 species are enumerated in this report, distributed thus :—

Brachyura	9	Amphipoda.........	34
Anomoura	7	Isopoda	5
Macroura............	7	Entomostraca......	16
Stomapoda	8	Pycnogonoidea ...	10
Cirripedia............	5		

The new species recorded were :—Mysis Didelphys, Vaunthompsonia rosea, Cyrianassa ciliata, C. elegans, Calliope bidentata, Heiscladus brevicaudatus, Nænia caudadentata, Phryxus longibranchialis, Cythere obesa, C. limicola, and another, unnamed, species of the same genus, Pallene attenuata, Nymphon brevirostre. The two new Pycnogons last named are described by the late Mr. George Hodge, the rest by Dr. Norman.

With regard to the Entomostraca a great deal of local information will be found in various papers, well known to specialists, by Professor G. S. Brady, M.D., F.R.S., and Dr. Norman,

INSECTS.

Space forbids the insertion of lists of the insects of the two counties. The entomologist is referred to the excellent and elaborate lists published by the late Mr. BOLD in the Tyneside, and by Mr. JAMES HARDY in the Berwickshire Transactions.

SPIDERS.

FROM THE REV. O. P. CAMBRIDGE'S "LIST OF ARANEIDEA AND PHALANGIDEA, COLLECTED IN BERWICKSHIRE AND NORTHUMBERLAND, BY MR. JAMES HARDY," (BERWICKSHIRE TRANSACTIONS, VOL. XII., NO. 2, 1874.)

Segestria senoculata, Linn.

Micaria pulicaria, Sund.

Drassus troglodytes, C. Koch.
D. lapidicolens, Walck.

Prosthesima Petiverii, Scop.
P. nigrita, Fabr.

Clubiona grisea, L. Koch.
C. terrestris, Westr.
C. pallidula, Clerck.
C. comta, C. Koch.
C. trivialis, C. Koch.
C. pallens, C. Koch.
C. reclusa, Cambr.

Dictyna arundinacea, Linn.

Amaurobius fenestralis, Stroem.

Cœlotes atropos, Walck.

Tegenaria Derhamii, Scop.

Textrix denticulata, Oliv.

Cryphoeca silvicola, C. Koch.

Hahnia elegans, Bl.

Pholcomma gibbum, Westr.

Theridion sisyphum, Clerck.
T. denticulatum, Walck.

T. pallens, Bl.

Phyllonettius lineata, Clerck.

Neriene atra, Bl.
N. promiscua, Cambr.
N. dentipalpis, Wider.
N. graminicola, Sund.
N. nigra, Bl.
N. tibialis, Bl.
N. longimana, C. Koch.
N. pygmœa, Bl.
N. rubens, Bl.
N. Huthwaitii, Cambr.
N. dentata, Wider.
N. agrestis, Bl.
N. retusa, Westr.
N. uncata, Cambr., first found at Wooler.
N. gibbosa, Bl.
N. apicata, Bl.
N. cornuta, Bl.
N. bituberculata, Wider.
N. excisa, Cambr.
N. livida, Bl.
N. rufa, Wider.
N. sylvatica, Bl.
N. fuscipalpis, C. Koch.
N. sublimis, Cambr., first found on the top of Cheviot.
N. curtipes, Cambr., first found at Langleyford.
N. pavitans, Cambr., first found on Cheviot.
N. clara, Cambr., first found on Cheviot.
N. prudens, Cambr., first found on Cheviot.
N. morula, Cambr., first found on Cheviot.

Walckenaera brevipes, Westr.
W. cuspidata, Bl.
W. unicornis, Cambr.
W. punctata, Bl.
W. bifrons, Bl.

W. cristata, Bl.
W. antica, Wider.
W. fuscipes, Bl.
W. obscura, Bl.
W. latifrons, Cambr.
W. permixta, Cambr.
W. nemoralis, Bl.
W. nodosa, Cambr.
W. trifrons, Cambr.
W. frontata, Bl.
W. acuminata, Bl.

Pachygnatha Clerckii, Sund.
P. Degeerii, Sund.

Tapinopa longidens, Bl.
T. unicolor, Cambr., first found on the Border.

Linyphia frenata, Bl.
L. thoracica, Wider.
L. leprosa, Ohl.
L. minuta, Bl.
L. tenebricola, Wider.
L. obscura, Bl.
L. variegata, Bl.
L. alacris, Bl.
L. socialis, Sund.
L. luteola, Bl.
L. alticeps, Sund.
L. cristata, Menge.
L. explicata, Cambr.
L. approximata, Cambr.
L. dorsalis, Wider.
L. ericæa, Bl.
L. circumspecta, Bl.
L. angulipalpis, Westr., new to Britain, when first found on Cheviot.
L. experta, Cambr.
L. rufa, Westr., new to Britain when first found on the Border.

L. bicolor, Bl.
L. reticulata, Cambr., first found in Cheviots. This is the only true Alpine form in the list.
L. prudens, Cambr., first found on the Border.
L. arcana, Cambr., first found on Cheviot.
L. contrita, Cambr., first found on Cheviot.
L. decens, Cambr.
L. concolor, Wider.
L. insignis, Bl.
L. clathrata, Sund.
L. bucculenta, Clerck.
L. montana, Clerck.
L. triangularis, Clerck.
L. peltata, Wid.
L. pusilla, Sund.
L. hortensis, Sund.

Ero thoracica, Wider.

Meta segmentata, Clerck.
M. Merianæ, Scop.

Tetragnatha extensa, Linn.

*Z*illa 4-notata, Clerck.
Z. atrica, C. Koch.

Epeira cucurbitina, Clerck.
E. diademata, Clerck.
E. cornuta, Clerck.
E. umbratica, Clerck.

Xysticus cristatus, Clerck.
X. viaticus, Clerck.
X. lanio, C. Koch.
X. erraticus, Bl.
X. atomarius, Panzer.
X. trux, Bl.
X. horticola, Panz.

Philodromus cespiticolis, Walck.

Thanatus oblongus, Walck.

Pirata piraticus, Clerck.

Trochosa cinerea, Fabr.
T. picta, Hahn.
T. ruricola, De Geer.
T. terricola, Thor.

Lycosa amentata, Clerck.
L. pullata, Clerck.
L. nigriceps, Thor.
L. herbigrada, Bl.
L. monticola, Clerck.
L. palustris, Linn.

Tarentula pulverulenta, Clerck.
T. andrenivora, Walck.

Epiblemum cingulatum, Panz.

Attus falcatus, Clerck.

The only Phalangid given in Mr. Cambridge's list as belonging to this region in Nemastoma chrysomelas, of which two examples had been found on Cheviot by Mr. James Hardy.

ANNELIDS.

Much information respecting the worms of the North East Coast will be found scattered through the many contributions of the late Dr. Johnston to the Berwickshire Transactions and elsewhere, but it is not possible to present a full list at present.

ECHINODERMS.

In the Dredging Expedition above referred to Professor G. S. Brady found the following :—

Ophiura texturata, Lam.
O. albida, Forbes.
O. Normani, Hodge.

Ophiocoma filiformis, Müll.

O. bellis, Link.
O. Goodsiri, Forbes.
O. rosula, Link.

Uraster glacialis, Linn.
U. rosea, Müller.
U. rubens, Linn.

Echinaster oculatus, Penn.

Solaster endeca, Linn.
S. papposa, Linn.

Asterias aurantiaca, Linn.

Luidia Savignii, Aud.

Echinus sphæra, Müll.
E. miliaris, Leske.
E. neglectus, Lam.
Echinocyamus pusillus, Müll.

Spatangus purpureus, Müll.

Brissus lyrifer, Forbes.

Amphidotus roseus, Forbes.

Ocnus lacteus, Forbes and Goodsir.

Thyone fusus, Müll.

Thyonidium commune, F. and G.
T. pellucidum, Vahl.

Psolus phantopus, Linn.

ZOOPHYTES.

THE FOLLOWING LIST, WITH A FEW ADDITIONS, IS TAKEN FROM THE LATE MR. ALDER'S "CATALOGUE OF THE ZOOPHYTES OF NORTHUMBERLAND AND DURHAM," IN VOL. III. OF THE TRANSACTIONS OF THE TYNESIDE NATURALISTS' FIELD CLUB, SEE ALSO VOL. V.

ANTHOZOA.

Clava multicornis, Forsk., not uncommon.

Vorticlava humilis, Alder, very rare.

Hydractinia echinata, Flem., frequent.
H. areolata, Alder, very rare.

Podocoryne Alderi, Hodge, very rare.

Coryne Listeri, Van Beneden, plentiful.
C. eximia, Allm., not rare.
C. Sarsii, Lov., very rare.
C. implexa, Alder, rare.
C. ramosa, Ehr., not rare.

Eudendrium rameum, Pallas., not rare.
E. ramosum, Linn., rare.

Dicoryne conferta, Alder, rare.
D. capillare, Alder, rare.

Atractylis repens, Wright, not rare.
A. linearis, Alder, not rare.
A. arenosa, Alder, not common.
A. ramosa, V. Ben., not rare.

Tubularia indivisa, Linn., not uncommon.
T. Dumortieri, Van Beneden, rather rare.
T. larynx, Ellis and Solander, frequent.

T. gracilis, Harvey, frequent.
T. simplex, Alder, not rare.

Corymorpha nana, Alder, very rare.
C. nutans, Sars, rare.

Halecium halecinum, Linn., common.
H. Beanii, Johnst., rather rare.
H. labrosum, Alder, very rare.
H. tenellum, Hincks, rare.
H. filiforme, Alder, very rare.
H. muricatum, Ellis and Solander, common.

Sertularia polyzonias, Linn., not rare.
S. Gayi, Lamou., occasional.
S. tricuspidata, Alder, not rare.
S. rugosa, Linn., frequent.
S. tenella, Alder, not common.
S. purnila, Linn., common.
S. rosacea, Linn., not uncommon.
S. Pinaster, Ellis and Solander, rare.
S. fallax, Johnst., frequent.
S. tamarisca, Linn., rare.
S. abietina, Linn., common.
S. filicula, Ellis and Solander, frequent.
S. operculata, Linn., common.
S. argentea, Ellis and Solander, common in places.
S. cuprenina, Linn., rare.
S. fusca, Johnst., rare.

Thuiaria thuia, Linn., frequent.
T. articulata, Pallas, rare.

Antennularia autennina, Linn., frequent.
A. ramosa, Lam., not uncommon.

Plumularia falcata, Linn., very common.
P. cristata, Lam., very rare.
P. halecioides, Alder. rare.
P. pinnata, Linn., not uncommon.
P. setacea, Ellis, frequent.

P. echinulata, Lam., not rare.
P. Catherina, Johnst., frequent.
P. myriophyllum, Linn., very rare.
P. frutescens, Ellis and Solander, rare.

Laomedea dichotoma, Linn., rather rare.
L. longissima, Pallas, frequent.
L. geniculata, Linn., very common.
L. flexuosa, Hincks Ms., frequent.
L. neglecta, Alder, frequent.
L. Loveni, Allm., not common.
L. lacerata, Johnst., not common.
L. acuminata, Alder, very rare.

Campanularia volubilis, Linn., frequent.
C. Johnstoni, Alder, common.
C. Hincksii, Alder, rather rare.
C. integra, J. Macg., not common.
C. syringa, Linn., not uncommon.
C. verticillata, Linn., not rare.
C. dumosa, Flem., common.
C. raridentata, Aider, occasional.
C. fruticosa, Sars, not rare.
C. humilis, Hincks, not common.

Reticularia serpens, Hassall, very abundant.

Grammaria robusta, Stimps., rather rare.

Coppinia arcta, Dal., frequent.

Hydra viridis, Linn., common.
H. vulgaris, Pallas, rather rare.

Pinnatula phosphorea, Linn., frequent.

Virgularia miriabilis, Linn., rare.
V. Christii, Kor. and Dan., rare.

*Z*oanthus Couchii, Johns., rare.
Z. Alderi, Gosse, very rare.

Alcyonium digitatum, Linn., very common.

Actinia mesembryanthemum, Ellis and Solander, common.
A. Troglodytes, Johnst., not rare (= Sagartia).
A. pellucida, Alder, not common (= Sagartia).
A. coriacea, Cuo., common (= Bunodes).
A. crassicornis, Müll, frequent (= Bunodes).
A. digitata, Müll, not rare (= Bunodes).
A. dianthus, Ellis, not common (= Actinoloba).

Stomphia Churchiæ, Gosse, very rare.

Anthea Tuediæ, Johnst., not rare.

Lucernaria auricula, Fab., not rare.
L. campanulata, Lam., rare.

POLYZOA.

Tubulipora patina, Lam., frequent.
T. hispida, Flem., not rare.
T. penicillata, Fab., very rare.
T. flabellaris, Fab., rare.
T. serpens, Linn., common.

Diastopora obelia, Johnst., frequent.

Alecto major, Johnst., not common.
A. granulata, M. Ed., rather rare.
A. dilatans, Johnst., rare.

Crisia eburnea, Linn., common.
C. denticulata, Lam., not common.

Crisidia cornuta, Linn., rather rare.

Eucratea chelata, Linn., common.

Hippothoa catenularia, Jameson, rare.

Anguinaria spatulata, Lam., not common.

Gemellaria loriculata, Linn., very abundant.

Cellepora pumicosa, Linn., common.
C. Hassallii, Johnst., not rare.
C. ramulosa, Linn., frequent.

C. Skeuci, Ellis and Solander, rather rare.
C. cervicornis, Ellis and Solander, not common.

Lepralia Brongniartii, Aud., rare.
L. auriculata, Hass., rare.
L. reticulata, J. Macg., not rare.
L. concinna, Busk., rare.
L. verrucosa, Esper., common.
L. unicornis, Johnst., rare.
L. trispinosa, Johnst., common.
L. coccinea, Johnst., frequent.
L. linearis, Han., common.
L. ciliata, Linn., not common.
L. variolosa, Johnst., rather rare.
L. nitida, Fab., rare.
L. bispinosa, Johnst., rare.
L. Peachii, Johnst., rare.
L. ventricosa, Hass., rare.
L. punctata, Hass., common.
L. Pallasiana, Moll., rather rare.
L. Malusii, Aud., not common.
L. granifera, Johnst., not rare.
L. hyalina, Linn., very common.

Membranipora membranacea, Linn., common.
M. pilosa, Linn., very abundant.
M. lineata, Linn., common.
M. spinifera, Johnst., common.
M. craticula, Alder, very rare.
M. Lacroixii, Aud., very rare.
M. Flemingii, Busk, common.
M. Pouilletii, Aud., frequent.
M. unicornis, Flem., frequent.

Flustrella hispida, Fab., common.

Cellularia scruposa, Linn., common.
C. scrupea, Busk, very rare.
C. reptans, Linn., frequent.
C. Peachii, Busk, rare.

Bicellaria ciliata, Bl., rare.

Menipea ternata, Ell. and Sol., not common.

Bugula avicularia, Linn., not common.
B. flabellata, Gray, not rare.
B. Murrayana, Johnst., rather rare.
B. fastigiata, Fab., common.
B. turbinata, Alder, very rare.
B. plumosa, Pall., rare.

Flustra foliacea, Linn., common.
F. truncata, Linn., abundant.

Carbasea papyrea, Pallas, frequent.

Eschara foliacea, Ellis and Solander, rare.
E. cribraria, Johnst., not common.

Retepora Beaniana, King, not rare.

Salicornaria farciminoides, Ellis and Solander, frequent.
S. sinuosa, Hass., rare.

Alcyonidium gelatinosum, Linn., frequent.
A. hirsutum, Flem., common.
A. lineare, Hincks, rare.
A. parasiticum, Flem., common.
A. mammillatum, Alder, not uncommon.
A. albidum, Alder, rare.
A. hexagonum, Hincks, frequent.
A. polyoum, Han. (?) frequent.

Arachnidium hippothooides, Hinks, rare.

Serialaria lendigera, Linn., not rare.

Vesicularia spinosa, Linn., rare.

Buskia nitens, Alder, rather rare.

Valkeria uva, Linn., frequent.

Bowerbankia imbricata, Adams, frequent.

Farrella pedicellata, Alder, not uncommon.

Avenella fusca, Dal., not common.

Pedicellina echinata, Sars., frequent.
P. Belgica, V. Ben., rare.
P. gracilis, Sars, common.

*Alcyonella stagnorum, Lam., rare, local.

Plumatella repens, Linn., rare, local.
*P. punctata, Hanc., rare, local.
*P. Allmani, Hanc, rather abundant locally.

*Fredericella sultana, Blum., abundant locally.

*Paludicella procumbens, Hanc., not rare locally.

PROTOZOA.

DR. H. B. BRADY, F.R.S., in the often-referred-to Dredging Report of 1862, recorded the following *Foraminifera*:—

Orbulina universa, D'Orb.

Lagena vulgaris, Williamson.

Entosolenia globosa, Walker.
E. costata, Will.
E. marginata, Walk.
E. squamosa, Mont.

Nodosaria radicula, Linn.
N. pyrula, D'Orb.

Dentalina subarcuata, Mont.
D. legumen, Linn.

Cristellaria calcar, Linn.

Nonionina crassula, Walk.
N. Jeffreysii, Will.

Polystomella crispa, Linn.
P. umbilicatula, Walk.

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* The species marked with an asterisk are from the Northumberland Lakes.

Patellina corrugata, Will.

Rotalina Beccarii, Linn.
R. turgida, Will.
R. concamerata, Mont.

Globigerina bulloides, D'Orb.

Planorbulina vulgaris, D'Orb.

Truncatulina lobatula, Walk.

Bulimina pupoides, D'Orb.
B. elegantissima, D'Orb.

Cassidulina lævigata, D'Orb.

Polymorphina lactea, Walk.

Textularia cuneiformis, D'Orb.
T. variabilis, Will.

Biloculina ringens, D'Orb.

Spiroculina depressa, D'Orb.

Miliolina trigonula, Lank.
M. seminulum, Linn.
M. bicornis, Walk.

For a complete Bibliography of the subject see Dr. H. B. Brady's magnificent " Monograph " on the Foraminifera in the *Challenger* Reports.

Several papers on certain special North Country sponges could be referred to, but no list can be yet given.

FLORA.

The whole of the following is taken, partly in abstract and partly as entire quotations, from Messrs. Baker and Tate's excellent "Flora" of the two counties, published in 1868, and forming Vol. II. of the Natural History Transactions of Northumberland and Durham.

With a long sea-margin, broad wooded and cultivated lowlands, wild craggy moorlands and upland pastures almost reaching a height of 3,000 feet above sea-level, it is not to be wondered that the Flora of Northumberland and Durham should be rich and varied. There are, in fact, some 1,450 native species of flowering plants, with ferns and their allies, in these two counties. These species are distributed as follows in relation to altitude :—

882	species	occur	below	450	feet.
581	"	"	at	450	"
541	"	"	"	600	"
495	"	"	"	750	"
450	"	"	"	900	"
407	"	"	"	1,050	"
375	"	"	"	1,200	"
326	"	"	"	1,350	"
300	"	"	"	1,500	"
212	"	"	"	1,750	"
135	"	"	"	1,800	"
108	"	"	"	1,950	"
66	"	"	"	2,100	"
54	"	"	"	2,250	"
34	"	"	"	2,400	"
20	"	"	"	2,550	"

Thalictrum flavum, Coronopus Ruellii, Lythrum salicaria, Heliosciadium nodiflorum, Bryonia dioica, Convolvulus arvensis, Nepeta cataria, Ballota nigra, Erythæa centaurium, Tamus communis, Pulicaria dysenterica, Hordeum pratense, are among the plants that do not occur above 300 feet.

Lepidium campestre, Papaver rheas, Barbarea vulgaris, Malva sylvestris, Epilobium hirsutum, Eupatorium cannabinum, Linaria vulgaris, Lamium album, Lithospermum arvense, Rumex conglomeratus, Ophioglossum vulgatum, Trifolium arvense, stop upwards at 600 feet.

Cardamine amara, Sisymbrium officinale, Viola hirta Hypericum perforatum, Rubus fruticosus, Geranium dissectum, Trifolium procumbens, T. minus, Arctium lappa, Mentha arvensis, Typha latifolia, Sparganium ramosum, stop upwards at 900 feet.

Cerastium glomeratum, Ulex europæus, Spartium scoparium, Prunus spinosa, Lotus major, Geum urbanum, Galium cruciatum, Fraxinus excelsior, Pyrus malus, Ulmus montana, Viburnum opulus, Quercus robur, stop upwards at 1,200 feet.

Capsella bursa-pastoris, Lonicera periclymenum, Hypericum pulchrum, Prunus Padus, Rosa canina, Juniperus communis, Populus tremula, Betula alba, Corylus avellana, Angelica sylvestris, Senecio aquaticus, Taxus baccata, Erica cinerea, stop upwards at 1,500 feet.

Ranunculus flammula, Polygala vulgaris, Stellaria graminea, Oxalis acetosella, Epilobium montanum, Cratægus oxyacantha, Parnassia palustris, Heracleum sphondylium, Carduus lanceolatus, Salix capræa, Lastrea filix-mas, stop upwards at 1,800 feet.

The following is a list of the species, about half the total number, which are Northern and montane for Britain as a whole, arranged according to the order in which they are to be met with as we ascend from the low country up amongst the hills.

Below 300 feet: Thalictrum minus, T. flexuosum, Trollius europæus, Thlaspi alpestre, Viola lutea, Arenaria verna, Stellaria nemorum, Geranium sylvaticum, Prunus Padus, Sanguisorba officinalis, Ribes nigrum, R. rubrum, R. grossularia, R. alpinum, Sedum villosum, Parnassia palustris, Ligusticum scoticum, Myrrhis odorata, Galium boreale, Crepis paludosa, Carduus heterophyllus, Campanula latifolia, Pyrola minor, Lamium intermedium, Galeopsis versicolor, Mertensia maritima, Pinguicula vulgaris, Primula farinosa, Salix pentandra, S. nigricans, S. laurina, S. phylicifolia, Listera cordata, Cypripedium calceolus, Allium scorodoprasum, Gagea lutea, Blysmus rufus, Scirpus uniglumis, Carex filiformis, Sesleria ærulea, Melica nutans, Aspidium lonchitis, Equisetum hyemale, E. umbrosum, Lycopodium selaginoides, Elymus arenarius.

At 300 feet: Drosera anglica, Callitriche autumnalis, Hieracium argenteum, H. crocatum, H. premanthoides, Sagina subulata, Gnaphalium dioicum, Andromeda polifolia, Pyrola media, Empetrum nigrum, Carex dioica, C. limosa, Polypodium phegopteris, P. dryopteris.

At 450 feet: Potentilla alpestris, Saxifraga aizoides, S. stellaris, Meum athamanticum, Galium sylvestre, Crepis succisæfolia, Hieracium pallidum, H. cæsium, H. gothicum, H. corymbosum, Vaccinium vitis-idæa, V. uliginosum, Trientalis europæa, Rumex aquaticus, Habenaria albida, Carex pauciflora, C. irrigua, Allosorus crispus, Asplenium viride, A. germanicum, A. septentrionale, Equisetum variegatum.

At 600 feet: Saxifraga hypnoides, Linnæa borealis, Hieracium lasiophyllum, Arbutus uva-ursi, Pyrola secunda, Polemonium cæruleum, Convallaria verticillata, Festuca sylvatica.

At 750 feet: Potentilla fruticosa, Polygonum viriparum.

At 900 feet: Thalictrum alpinum, Cornus suecica, Hieracium anglicum, H. iricum, Melampyrum sylvaticum, Lycopodium alpinum.

At 1,050 feet: Gentiana verna, Bastia alpina.

At 1,200 feet: Sedum rhodiola, Saxifraga hirculus, Tofieldia palustris, Carex capillaris.

At 1,350 feet: Draba incana, Woodsia ilvensis.

At 1,500 feet: Rubus chamæmorus, Epilobium anagallidifolium, Juncus triglumis.

At 1,750 feet: Carex rigida.

The following lists show the distribution of plants in the region according to the rocks outcropping therein.

PLANTS PECULIAR TO THE LIMESTONE.

(Those marked with an asterisk are confined to the Magnesian Limestone.)

Aquilegia vulgaris, Draba incana, Arabis hirsuta, Helianthemum vulgare, Viola hirta, Cerastium arvense, Arenaria verna, *Linum perenne, *Hypericum montanum, Geranium sanguineum, Anthyllis vulneraria, Astragalus glyciphyllus, A. hypoglottis, *Onobrychis satifer, Spiræa filipendula, Rubus saxatilis, Poterium sanguisorba, Pyrus aria, Galium sylvestre, Scabiosa columbaria, *Carduus eriophorus, Carlina vulgaris, Campanula glomerata, *Ligustrum vulgare, Polemonium cæruleum, Gentiana verna, G. amarella, Atropa belladonna, Salvia verbenaca, Origanum vulgare, Calamintha nepeta, Taxus baccata, *Orchis ustulata, O. pyramidalis, *Ophrys apifera, *O. muscifera, Cypripedium calceolus, Convallaria majalis, Sestera cærulea, Avena pratensis, Melica nutans, *Bromus erectus, Hordeum sylvaticum, Polypodium calcareum.

List of plants characteristic of, though not restricted to, the sandstone: Orobus tuberosus, Prunus Padus, Betula alba, Spartium scoparium, Quercus sessiliflora, Alnus glutinosa, Calluna vulgaris, Aira flexuosa, Hieracium boreale, Ononis spinosa, Jasione montana, Hypericum pulchrum, Stellaria holostea, Galeopsis ochrolenca, Trifolium frugiferum, Luzula multiflora, Filago minima, Aira cæspitosa, Alopecurus pratensis, Triodia decumbens, Rumex acetosella, Montia montana, Nardus stricta, Hypericum humifusum, Senecio sylvaticus, S. aquaticus, Arenaria rubra, Lotus major, Vaccinium myrtillus, Juncus squarrosus, Meum athamonticum, Digitalis purpurea, Galium saxatile, Saxifraga stellaris, Asplenium septentrionale.

Plants common on porphyrite: Draba verna, Arabis hirsuta, Sisymbrium thalianum, Helianthemum vulgare, Dianthus deltoides, Cerastium triviale, Sagina procumbens, Viola sylvatica, Geranium Robertianum, Hypericum pulchrum, Spartium scoparium, Rosa spinosissima, Pimpinella saxifraga, Hedera helix, Galium cruciatum, G. verum, G. sylvestre

Hieracium pilosella, H. vulgatum, Leontodon taraxacum, Apargia autumnalis, Carduus lanceolatus, C. arvensis, Centaurea nigra, Achillea millefolium, Campanula rotundifolia, Veronica arvensis, Digitalis purpurea, Teucrium scorodonia, Myosotis arvensis, Plantago lanceolata, Rumex acetosella, Urtica dioica, Festuca ovina, Avena pratensis, A. flavescens, Aira præcox, Anthoxanthum odoratum, Poa nemoralis, Agrostis vulgaris, Polypodium vulgare, Pteris aquilina.

Plants on the Granite: Ranunculus repens, Cardamine pratensis, Sagina procumbens, Stellaria uliginosa, Cerastium triviale, Viola palustris, Rubus chamæmorus, Potentilla tormentilla, Galium saxatile, Saxifraga stellaris, Chrysosplenium oppositifolium, Montia fontana, Campanula rotundifolia, Calluna vulgaris, Vaccinium myrtillus, V. vitis-idæa, Euphrasia officinalis, Empetrum nigrum, Rumex acetosa, Luzula sylvatica, L. multiflora, Eriophorum vaginatum, E. angustifolium, Carex rigida, C. stellulata, Aira flexuosa, Anthoxanthum odoratum, Agrostis vulgaris, Poa annua, Festuca ovina, Nardus stricta, Lastræa dilatata, Blechnnum boreale, Lycopodium selago, L. alpinum.

Plants found on Basalt: Thalictrum flexuosum, Viola sylvatica, Helianthemum vulgare, Ulex europæus, Spartium scoparium, Lotus corniculatus, Euonymus europæus, Rosa spinosissima, Rubus umbrosus, R. radula, Prunus spinosa, Sedum acre, Lonicera periclymenum, Hedera helix, Galium cruciatum, G. verum, Solidago virgaurea, Hieracium vulgatum, Achillea millefolium, Calluna vulgaris, Erica cinerea, Vaccinium myrtillus, Pyrola media, Ilex aquifolium, Thymus serpyllum, Teucryum scorodonia, Quercus robur, Juniperus communis, Convallaria polygonotum, Triodia decumbens, Brachypodium sylvaticum, Agrostis vulgaris, Festuca ovina, Aira caryophyllea, A. præcox, Pteris aquilina. (This is the florula of an actual crag of the Whin Sill, at Kyloe; Mr. Tate gives the following as being found only on Basalt in Northumberland). Mænchia erecta, Sagina subulata, Vicia lathyroides, Asperugo procumbens, Statice limonium, Convallaria polygonatum, Allium schœnoprasum, Scilla verna, Sedum anglicum, Asplenium septentrionale, A. germanicum and Polemonium cæruleum. Spergularia rubra, and Filago minima, though not restricted to the Basaltic outcrops, are commonest there.

BALLAST PLANTS.

On the ballast heaps, which form distinct features about the mouths of the Tyne, Wear, and Tees, are found from time to time a considerable number of plants foreign to the district. "We believe," say Messrs. Baker and Tate, "that it rarely happens that any of these ballast introductions ripen seed and spring up a second time, so that when fresh importations cease they disappear speedily. Although we see that this ballast list includes more than one hundred and fifty species, ... Reseda lutea, Sinapis tenuifolia, Pastinaca sativa, and perhaps three or four of the Chenopodiacæ, are all that are at all likely to have been introduced in this way" into the list of native plants.

Clematis vitalba, Ranunculus hirsutus, R. muricatus, Delphinium ajacis, Nigella arvensis, N. damascena, Papaver hybridum, Argemone mexicana, Glaucium luteum, Fumaria micrantha, F. Vaillantii, Coronopa didyma, Lepidum draba, L. hirtum, L. sativum, L. ruderale, Camelina sativa, Farsetia incana, Nasturtium amphibium, Sisymbrium iris, S. austriacum, Erysimum cheiranthoides, E. orientale, Brassica oleracea, Sinapis tenuifolia, S. muralis, S. cheiranthus, S. monensis, Raphanus maritimus, Rapistrum rugosum, Reseda odorata, R. fruticulosa, Frankenia lævis, Dianthus armeria, Silene cornica, S. anglica, S. otites, Cerastium aquaticum, Linum perenne, L. angustifolium, Lavatera arborea, L. trimestris, Erodium maritimum, E. moschatum, Geranium pyrenaicum, G. rotundifolium, Medicago sativa, M. falcata M. maculata, M. minima, M. denticulata, M. prostrata, M. coronata, M. rigidula, Melilotus vulgaris, M. arvensis, M. messanensis, Trifolium subterraneum, T. ochroleucum, T. maritimum, T. glomeratum, Scorpiurus vermiculata, Ornithopus perpusillus, O. compressus, Onobrychis sativa, Vicia bithynica, V. bengalensis, Lathyrus Aphaca, L. sylvestris, L. nissolia, L. hirsutus, L. ochrus, Rosa Borreri, Œnothera biennis, Claytonia perfoliata, Herniaria hirsuta, Mesembryanthemum crystallinum, M. falcatum, M. glomeratum, Eryngium campestre, Petroselenium sativum, Lison amomum, Fœniculum vulgare, Pastinaca sativa, Fordycium syriacum, Cuminum cyminum, Dipsacus fullonum, D. pilosus, Picris hieracioides, Barkhausia taraxacifolia, Carduus eriophorus, C. setosus, Galactites tomentosa, Calendula arvensis, C. officinalis, Centaurea jacea, C. calcitrapa, C. solstitialis, C. orientalis, Artemisia campestris, Inula coryza, Anthemis tinctora, A tomentosa, A. valentina, A. mixta, Xanthium strumarium, Specularia hybrida, Convolvulus tricolor, Hyoscyamus albus, H. aureus, Solanum nigrum, Verbascum nigrum, V. Blattaria, Antirrhinum orontium, Linaria spuria, L. elatine, L. repens, L. minor, Calamintha nepeta, Borago officinalis, Anchusa officinalis, Echium italicum, Chenopodium olidum, C. polyspermum, C. urbicum, C. murale, C. hybridum, C. ficifolium, C. glaucum, Amaranthus Blitum, Blitum vergatum, Atriplex pedunculata, A. hortensis, Scoberia fruticosa, Polygonum fagopyrum, Rumex maritimus, R. palustris, Euphorbia amygdaloides, E. spinosa, Pedilanthus tithymaloides, Mercurialis annua, Urtica pilulifera, Cannabis sativa, Digitaria sanguinalis, Seteria verticillata, S. viridis, Polypogon monspeliensis, Phalaris canariensis, P. paradoxa, Cynosurus echinatus, Bromus arvensis, B. madritensis, B. maximus.

SUMMARY.

1. Adapting the Northumberland and Durham list to the standard, as regards specific limits, of Watson's *Cybele Britannica*, we claim for the two counties taken together nine hundred and thirty-five species out of the one thousand four hundred and twenty-five, which are yielded by the whole of Britain, exclusive of Ireland, and besides those we have enumerated, two hundred and four casual introductions, eighty-seven of which are stray garden plants, or occasional cornfield weeds, the

other one hundred and seventeen plants introduced with ballast.

2. Out of these nine hundred and thirty-five species, which we consider we may fairly claim for the two counties, at least eighty-nine seem more likely to have been introduced by human agency than to be genuine aborigines, but it is of course impossible to draw the line between the two classes with any precision. In this eighty-nine we include sixty-three well-established weeds of cultivated ground, and twenty-six which are either trees or plants likely to have been introduced through garden cultivation.

3. Classing the plants of the two counties according to the types of distribution of the *Cybele Britannica* we obtain the following result:—

	Whole of Britain.	Northumberland and Durham.
British type	532	532
English ,,	409	251
Germanic ,,	127	26
Atlantic ,,	70	5
Highland ,,	120	36
Scottish ,,	81	57
Intermediate type	37	21
Local type	49	7
Total	1,425	935

If we arrange the plants of Britain on the basis of this last table, in three principal geographical classes, according as they are distributed over its whole extent, or show a northern or southern tendency, we shall of course find the characteristic peculiarities of the botany of the different parts of the island as compared with one another, in the absence or presence of the plants of the two last classes. The characteristic of the North of England is that it yields a fair proportion of both of them. In Northumberland and Durham we had one hundred and fourteen out of the two hundred and thirty-eight northern and montane plants, and two hundred and eighty-two out of the six hundred and six comparatively southern species. Of the eighteen botanical provinces defined in the *Cybele*, the richest in number of species are those of the south-east of England. The Thames Province, which includes Kent, Surrey, Berks, Oxford, Bucks, Middlesex, Herts, and Essex, an area of 7,000 square miles, yields one thousand and fifty-one species. The Channel Province, which includes Dorset, Wilts, Hants, and Sussex, 5,464 square miles, yields one thousand and forty species. Next to these comes the Humber Province, which is conterminous with Yorkshire, has an area of 5,836 square miles, and yields one thousand and fifteen species. This number is higher than that of the Midland provinces, because, although in the latter the number of southern species is greater than that in Yorkshire, the number of northern ones is very much fewer. As compared with Yorkshire, the Tyne Province has only about half its area, and eighty fewer plants. In northern species they are nearly upon an equality, the difference between the two being almost altogether caused by the absence beyond the Tees of southern plants, which run out in Yorkshire. For the northern half of Wales we know nine hundred and thirty-eight species, for the Mersey Province, which includes Cheshire and Lancashire, eight hundred and forty-two, for the two lake counties and Isle of Man, eight hundred and sixty, but for none of these three have Floras been written,* and we cannot consider their lists complete, whilst for our own province, we cannot expect any material increase.

5. We have seen in Yorkshire how rapidly the southern types thin out; through our two counties this continues in a marked manner, and the following thirty-seven species which we have admitted fail to reach Scotland, twenty-eight reach Cheviot-land, viz.:—Humulus lupulus, Allium schænoprasum, Glycera procumbens, Arundo calamagrostis, Convallaria polygonatum, Mænchia erecta, Euphorbia amygdaloides, Populus alba, Ulmus campestris, Juncus diffusus, Ribes grossularia, R. nigrum, Verbena officinalis, Agrimonia odorata, Orchis morio, Atropa belladonna, Helmintha echioides,

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* This was written more than twenty years ago.—*Editor.*

Solanum nigrum, Chenopodium urbicum, Galium tricorne, Hippophae rhamnoides, Lepidum latifolium, Rubus discolor, R. diversifolius, Rosa rubiginosa, Orobanche minor, Rosa systyla, Narcissus pseudo-narcissus.

Eighteen stop short in Tyne-land, viz.:—Myosurus minimus, Medicago maculata, Myriophyllum verticillatum, Brionium dioica, Apera spica-venti, Hordeum sylvaticum, Chenopodium glaucum, C. murale, Scrophularia aquatica, Convallaria multiflora, Taxus baccata, Helleborus viridis, Lactuca muralis, Rubus leuchostachys, Orchis ustulata, Tamus communis, Helleborus fœtidus, Cuscuta trifolii.

Thirty-one stop short in Durham, viz.:—Picris hieracioides, Daphne mezereum, Inula helenium, Cornus sanguinula, Acer campestre, Lysimachia nummularia, Viola odorata, Hypericum montanum, Mentha pulegium, Rhamnus catharticus, Polypodium calcareum, Ophrys muscifera, Colchicum autumnale, Hortonia palustris, Linum perenne, Galeopsis ochrolenca, Ligustrum vulgare, Carduus eriophorus, Onobrychis sativa, Hordeum maritimum, Iris fœtidissima, Butomus umbellatus, Hydrocharis morsus-ranæ, Bupleurum tenuissimum, Ophrys apifera, Ranunculus parviflorus, Papaver hybridum, Bupleurum rotundifolium, Caucalis daucoides, Cypripedium calceolus, Specularia hybrida.

6. Only one species is restricted in Britain to our two counties, the Teesdale Arenaria uliginosa, and that has a wide distribution on the Continent, reaching from Lapland to Lombardy and Austria. A second Teesdale species, only discovered, or rather determined, very recently, Viola arenaria, has still more recently been found over the Westmorland border; and sixteen of the northern species are not found further south on the east side of the island, viz. :—Juncus triglumis, Epilobium anagallidifolium, Woodsia ilvensis, Linnæa borealis, Hieracium lasiophyllum, Convallaria verticillata, Vaccinium uliginosum, Asplenium germanicum, Carex irrigua, Hieracium argentum, Callitriche autumnalis, Ligusticum Scoticum, Lamium intermedium, Blysmus rufus, Mertensia maritima, Carex incurva.

7. Dividing the surface of the two counties into three zones of altitude and climate, as explained already, only thirteen species

out of the nine hundred and thirty-five do not grow somewhere in the lower one, whilst four hundred and eighteen species ascend into the middle zone, and only one hundred and eight into the highest of the three. Fifty species are essentially restricted to the sea coast, and forty-five show a decided preference for the dry-soiled and especially the limestone tracts.

THE FUNGI OF NORTHUMBERLAND AND DURHAM.

MR. FARADAY SPENCE, of Hexham, has favoured me with the following notes:—

The extensive woods which border so many of the streams of the two counties afford most favourable conditions for the growth of Fungi, which accordingly are found in great profusion and variety. The meadows and pastures, and even the moorlands, have their distinctive species in fair number, so that it is somewhat remarkable that no catalogue of the various kinds has been published since the earlier part of the century.

The earliest local students of this subject, whose names have been preserved, were Mr. F. Scott, of Hexham, Mr. R. Wilson, of Medomsley, and Mr. E. Robson, of Darlington, whose observations were incorporated in the 2nd vol. of the "Botanist's Guide through the Counties of Northumberland and Durham," published in 1807, by Nathaniel J. Winch, F.L.S., John Thornhill, and Richard Waugh. The system of classification adopted was that of Dr. Withering in his "Arrangement of British Plants," which, however, soon became obsolete, as further investigations with improved microscopes proved it to have been based on erroneous notions. It is difficult, if not impossible, to trace the specimens recorded in this Flora, as in most cases the generic names have been altered, and frequently the specific also.

A second Flora, by Mr. Winch, was published in the "Transactions of the Natural History Society of Northumberland and Durham" for 1832. It is not clear whose system of classification was adopted, but Persoon, De Candolle, Fries, and Greville are quoted, though the author despairingly writes of Fungi—"their very genera are almost as unsettled as the sands of the sea shore." As Mr. Winch makes no reference whatever to his former work, not even to the change in nomenclature and classification, it may be presumed that he himself regarded it as obsolete. The list of Fungi was now extended to 94 genera, containing 548 species.

A Flora of Berwick-on-Tweed, by George Johnston, M.D., was published in 1831, which contains descriptions of 327 Fungi, though the author modestly says: "This will probably be found to be a very imperfect list of the agarics of North Durham and Berwickshire, for in the immediate vicinity of Berwick there is no place very favourable for their production." He does not give the authority for his classification, which, indeed, appears to have been his own.

These two works, with all their disadvantages of obsolete and untraceable nomenclature, remain the latest local publications on this branch of botany.

Popular knowledge on this subject appears to be represented by the belief that whatever Fungus is not a mushroom is probably poisonous. The only exception is that of the "rare" Morel (Morchella Esculenta) which is deservedly valued in the country. Unfortunately it is rare in quantity as well as in quality.

Other edible Fungi are well represented; Lactarius Deliciosus grows luxuriantly in certain woods near Hexham, and the nutty-flavoured Boletus Edulis in others. The apricot-scented Cantharellus Cibarius is plentiful on the Devil's Water, and exceptionally fine specimens have been gathered in Gallows Wood, near Hexham. Hydnum Repandum, or the Hedgehog Mushroom, grows profusely near Blanchland. Two of the most delicious Fungi, the Beef-steak Fungus Fistulina Hepatica and the Giant Puff Ball Lycoperdon Giganteum are scarce, yet both have been gathered in the grounds of Beaufront Castle. Helvella Lacunosa was found growing plentifully near Hexham in the winter of 1886, although it was frozen every night.

Among the better known poisonous varieties may be mentioned the beautiful, though deadly, white Amanite, Agaricus Phalloides, the strangely coloured Boletus Luridus, the "Destroyer," Agaricus Necator, the Griping Mushroom, Lactarius Torminosus, the Biting Mushroom, Marasmius Urens, and others which may readily be found.

The East Common Wood, Hexham, is given by Mr. F. Scott as a *habitat* so often, that it appears to have been a most fruitful ground, and it is interesting to note that it still remains so; 67 species of the larger Fungi having been gathered there recently in one afternoon.

It may be mentioned that in the natural history museum at Newcastle-on-Tyne there is a collection of models of over 100 kinds of Fungi.

There are in the two counties many good stations offering a wide field for research in this interesting but much neglected subject.

SEA WEEDS.

In Vol. IV. of the Tyneside Field Club Transactions (1860), is a full catalogue of the Marine Algæ of Northumberland and Durham, by Professor G. S. Brady, M.D., F.R.S., a much fuller one than the early list given by the late N. J. Winch, in his "Flora." It is not proposed to enumerate the species here. The following table, quoted from Professor Brady's paper, will convey an idea, so far as our information extends, of the number of species existing in our district :—

	Number of British Species.	Local Species. (Total)	Of which are found only in Northumberland.	Durham.
Melanospermeæ...	100	55	13	8
Rhodospermeæ ...	186	87	20	7
Chlorospermeæ ...	104	34	6	4
	390	176	39	19

INDEX OF PERSONS AND PLACES.

Acklington, 52, 85, 86, 88, 105.
Acomb, 17, 66, 67.
Acre, 63, 69, 70.
Ad Fines Camps, 151.
ALDER, J., 169, 181, 190.
Adderstone, 13.
Allendale, 20, 135.
Allendale, West, 89, 137.
Allenheads, 62, 63, 136.
Allerdean, 69.
Allerwash, 61.
ALLPORT, SAMUEL, 101.
Aln, 16, 25, 133.
Alnmouth, 12, 60, 110.
Alnwick, 13, 21, 58, 67, 96, 97, 122, 129, 130.
Alston, 60-63, 66, 135, 137.
Alston Moor, 58, 136, 137.
Alwin, 7, 8, 85, 106.
Alwinton, 8, 79, 106, 137.
Andrew's Close, 67,
Andrew's House, 24.
Angerton, 10, 14.
Annstead, 133.
Apperley, 109.
Ashgill, 136.
ATKINSON, J. B., 56.
ATKINSON, J. J., 39.
ATTHEY, T., 41, 152.
Ayton, 145.

BAKER, J. G., 198
Bamburgh, 12, 21, 22, 27, 97, 98.
Bardon Mill, 63, 70.
Barmpton, 31.
Barnard Castle, 5, 52.
Barrow Scroggs, 79.
Bavington, 89, 95, 136.
Bavington, Great, 94.
Bavington Hall, 24, 90.
Bavington, Little, 67.
Bavington, West, 67.
Beacon, The (Holy Island), 14, 19.
Beacon Hill, 73.
Beadnell, 63, 69, 70, 88, 97.
Beadnell Bay, 97.
Beal, 12.
Bedlington, 88.
Belford, 100.
Belsay, 27, 60, 66, 70, 156.
BELL, Sir L., 85.
BELL, T. H., 30.
Belling, The, 90, 130.
Bellingham, 67, 156.
Benwell Hill, 44.
Bernicia, 20, 74, 81.
Berry Hills, 93.
Berwick. 12, 21, 67, 77, 123, 124.
Bewcastle, 147.
Biddlestone, 76, 79, 85, 104.
Billsmoor Park, 71, 90.
Billy Mill, 87.
Bingfield Burn, 89.
BINNEY, E. W., 34.
Bishop Auckland, 5, 36, 108.
Black Burn, 90.
Black Law, 107.
Black Pasture Quarry, 61.
Black Rocks, 32.
Blackhill, 69, 70.
BLAKE, Dr. C. C., 20.
BLAKE, Rev. J. F., 145.

Blanchland, 57, 136.
Blenkinsopp, 67.
Blind Burn, 151.
Bloody Moss, 11.
Blyth, 12, 25, 42.
Boghall, 67.
Bolam (Northumberland), 90.
Bolam (Durham), 85.
BOLD, G., 184.
Boldon Colliery, 47.
Boldon Flats, 19.
Boldon, West, 34, 37.
Bondicar, 88.
Boulby, 142.
Boulmer, 90.
Bounder End, 136.
Bowhope Head, 151.
BOYD, E. F., 26, 77, 97.
Bradford Kaims, 21, 22.
BRADY, Prof., 183, 188, 210.
BRADY, H. B., 62, 124, 196, 197.
BRAMWELL, H., 91.
Breamish, 9, 102.
Brier Edge, 67.
Brinkburn, 63, 130.
Bristol, 81.
Brockley Whins, 47.
BROWELL, E. J., 32.
BROWN, M. W., 134.
Brownlees, 67.
BRUCE, Dr. J. C., 60.
Brunton, 89.
BUDDLE, J., 47.
Budle, 12, 98, 122.
BULMAN, G. W., 15.
BURNS, D., 16, 95, 96.
Burnt Divot, 11.
Burradon, 44.
Burtreeford, 136, 137.
Byker, 44, 87.

Cairnglastenhope, 11.
Caldron Snout, 100.
Caldside, 69.
Callalee, 71.
Cambo, 67, 155.
CAMERON, J., 108.
CAMBRIDGE, Rev. O. P., 184, 188.
CANDOLLE, — de, 209.
Carham, 21, 80, 107, 140.
Carrick, High, 90.
Carriteth, 67.
Carrock Fell, 103.
Carrycoats, 67.
Carter Fell, 72, 83, 105, 106, 150.
Cartington Castle, 88.
Cassop, Old, 35, 37.
Castle Eden Dene, 32.
Cawledge Mill, 13.
CHAPMAN, A. C., 168.
Charnwood Forest, 103.
Chathill, 22.
Chesterholm, 130.
Cheviots, The, 3-5, 7-9, 11, 24, 76, 79, 82, 85, 88, 102, 103-107, 139, 149, 150, 151, 192, 185, 186, 187, 188.
Chillingham, 78, 131, 134, 147, 157.
Chirdon Burn, 13.
Chirm, The, 61, 68, 70.
Chollerton, 24, 95.
Chopwell Woods, 56.
Christenbury Crags, 72.
CLAPHAM, A., 42, 43.
Clarence Works, 34.
Clarewood, 67.
Claxheugh, 36, 37, 109.
Cleadon, 19, 87.
Cleadon Laws, 37.
Clennell, 85, 88, 102.
Clennell Street, 79, 106.
Cleveland Hills, 86, 142-145.
Closing Hill, 35, 37, 47.

Clough, C. T., 82, 102, 149 150.
Clyde, 22.
Coal House Quarries, 90.
Coalcleugh, 136.
Coaley Hill, 87.
Cockfield, 50, 85, 91.
Coldstream, 91.
Collywell, 86.
Condercum, 44.
Coniscliff, 32.
Consett, 56.
Coquet, 7, 15, 16, 23, 25, 51, 56, 59, 61, 63, 71, 73, 77, 79, 82, 88.
Coquetdale, 5, 72, 78, 102.
Corbridge, 4, 5, 14, 25, 51, 60, 70, 156.
Cornhill, 91.
Cottonshope Head, 105.
Countess Crag, 72.
Cowden, 67, 70.
Cowen, J., 46.
Cowpen, 48.
Coxhoe, 49.
Coxhoe Colliery, 37.
Coxhoe House, 35.
Cramlington, 49, 88.
Craven, 81.
Croft, 31, 32.
Cross Fell, 65, 81.
Cullercoats, 5, 35, 37, 45, 108, 133, 158.
Cumberland, 5, 51, 58, 72, 103, 146.

Daglish, J., 19, 34, 39, 42, 43.
Darden Lough, 11, 90.
Darlington, 31.
Dawkins, Prof. W. B., 78.
Deadwater Fell, 72.
Debdon, 88.
Denton, 5, 48.
Denwick Lane, 130.
Derbyshire, 59, 81.
Derwent, 10, 16, 25, 45, 50, 55-57, 135-137.
Derwentcote, 56.
Dewley, 87.
Dinning, W., 16.
Doddington, 27.
Drake Stone, 72, 102.
Dryburn, 68, 111.
Duff, J., 36, 108.
Dunn, J. T., 96.
Dunstanburgh, 97, 99.
Dunston, 151.
Durham (City), 25.
Durham (County), *passim.*
Durham, Monument, 34.
Dyke-Head, 96.
Dyke-nook, 8.

East Common Wood, 210.
East Woodburn, 23, 71.
Eden, 16.
Eelwell, 64, 69.
Eglingham, 69.
Eldon, 35.
Elf Hills, 62, 95, 96, 101.
Elliot, J., 20.
Ellis Crag, 72.
Elsdon, 8, 11, 67, 90, 149.
Elsdon Burn, 90.
Elswick, 50.
Eltrincham, 56.
Embleton, 97.
Embleton, Dr. D., 158.
Erring Burn, 24.
Eston, 28, 29, 142, 145.
Evans, Dr. J., 20.

Fallowfield, 136, 137.
Fallowlees Burn, 96.
Falstone, 90.
Farne Islands, 97, 158.
Favell, T. M., 87.
Fawdon Burn, 82, 83.

Fawcett, 69.
Felling, 49.
Fenham, 89.
Ferryhill, 36, 37.
Fleetham, 69.
Flodden, 15.
Font, 9, 66,
Forest Burn, 96.
FORSTER, G. B., 34, 39.
FORSTER, WESTGARTH, 58, 59, 65, 137.
Fourstones, 70, 130.
Foxton Hall, 60, 110, 111.
Frenchman's Bay, 33.
FRIES, —, 209.
FRYAR, M., 97.
Fulwell, 34.

Gallow Hill, 96.
Gallows Wood, 209.
Gateshead, 16, 44, 134.
GEIKIE, Dr. A., 74, 75, 85.
GEIKIE, Prof. J., 106.
Glororum, 22, 27.
Golden Pot, Outer, 150.
Goldstone, The, 88.
GOODCHILD, J. G., 75.
Gosforth, 41, 45, 48, 109.
Grange Hill, 35.
Grasslees, 72, 73.
Great Bavington, 94.
Great Whittington, 67.
Green Eyes Crag, 68.
Greenhead, 92, 93.
Greenlee Lough, 67.
Greenlees, 67.
Greenleighton, 96.
Greenses, 69.
Greenside, 5.
GREVILLE, —, 209.
Grindon, 31.
Groby, 103.
Guisborough, 142, 145.
GUNN, W., 14, 82.
Gunnerton, 93.
HALL, T. Y., 51.
Halton Shields, 61.
Haltwhistle, 11, 15, 16, 62, 67, 71, 123.
Haltwhistle Burn, 63.
Hampeth Burn, 91.
HANCOCK, J., 159.
HANCOCK, A., 108.
Harbottle, 7, 72, 73, 77, 78, 102, 134, 147.
Harden Edge, 151.
HARDY, J. 184, 188.
Harelaw, 126-128.
Hareshaw, 89, 121, 126-128.
Hareshaw Head, 67.
Harkess Rocks, 98, 99.
Harlow Hill, 56, 60, 110, 130.
HARRIS, W. SCORER, 24.
Hartington, 96, 136.
Hartlepool, 33.
Hartlepool, West.
Hartley, 35, 37, 43, 136.
Harton, 37, 135.
Hartside Pike, 71.
Haughton Castle, 95, 100.
Haughton-le-Skerne, 31.
Haverton Hill, 29, 31.
Haydon Bridge, 15, 61, 62, 89, 136.
Headlam, 35.
Heathery Burn, 20.
Heaton Mill, 91.
Hebburn, 27, 48, 87, 91.
Hedgehope, 102.
Hedworth, 87.
Hepple, 79.
Hetchester, 79.
Hett, 86.
Hetton, 48.
Hetton-le-Hole, 37.
Heworth Colliery, 43.
Hexham, 66, 208, 209.
High Carrick, 90.

High Cup Nick, 100.
High Downs, 37.
High Force, 80, 82, 100, 107.
High Green, 90.
Hindhope, 106.
Hobb Hill, 145.
Hobberlaw, 69, 97, 129.
Hodge, G., 183.
Holy Island, 12, 14, 19, 85, 88.
Holystone, 72, 79.
Holywell Dene, 86.
Homilton, 95.
Hope House, 130.
Hoppen, 22.
Horsley, 8, 72.
Houghton-le-Spring, 37.
Howchin, Rev. W., 18, 20, 25, 62, 77, 122.
Howgate, 69.
Howick, 12, 14, 91, 97, 133.
Howse, R., 13, 19, 27, 34, 35, 78, 108, 109, 152.
Humbleton Hill, 108.
Huntcliffe, 142.
Hurst, G., 43.
Hurst, T. G., 52.
Hutton, 145.
Hutton, W., 47, 97, 109.
Huxley, Prof. T. H., 20.

Inghoe, 60, 61, 65-67, 70, 131, 140.
Ingleborough, 55.
Ingram, 82, 104.
Irthing, 11, 15, 16, 25, 72, 130.

Jack, —, 85.
Jarrow, 48.
Jarrow Slake, 12.
Jenkinson, Rev. E., 111, 130.
Johnston, Dr., 188, 209.
Jones, Prof. T. Rupert, 126.

Kendall, J. D., 144.
Kenton, 44.
Kielder, 149.
Killerby, 35.
Killingworth, 35, 37, 44.
Killingworth House, 47.
Kinderscout, 55.
King, Prof. W., 108, 180.
Kirkby, 13, 32, 34, 108, 109.
Kirkleatham, 145.
Kirkwhelpington, 95, 136.
Knowes Gate, 11, 93.
Knucton, 100.
Kyloe, 89, 100, 202.

Lake District, 83.
Lakes, Northumberland, 196.
Lamberton, 77, 78, 123, 124.
Lancashire, 54.
Langleyford, 185.
Langley Barony, 136.
Lapworth, Prof. C., 82.
Leitham, 89.
Lewis Burn, 68, 70, 90, 129.
Licker, 61, 68.
Liddell Water, 72.
Liddisdale, 146.
Lindisfarne, 88.
Lindley, Dr. J., 109.
Linnshiels, 72.
Lippwood, 62.
Lisle Burn, 23.
Little Bavington, 67.
Little Scar, 31.
Littletown, 37.
Lizards, Whitburn, 19.
Long Scar, 31.
Lough, Darden, 11, 90.
Lough, Greenlee, 67.
Lough House, 14.
Low Teppermoor, 93.
Lowdean, 63.
Lowick, 6, 63, 64, 68, 89, 111, 112, 115, 127, 130, 156.

Lucker, 22.
Ludworth, 37.
Lumley Colliery, 135.
Lumsdon, 9.

Makendon, 82, 105.
Marley Hill, 24.
Marsden, 19, 32-34.
Marske, 142, 145.
Marshall Green, 56.
Matfen, 60, 62, 65.
Matalees, 91.
McCoy, Prof. F., 112.
Medomsley, 50.
Melmerby Scar, 66, 70, 81.
Merrington, 34.
Midderidge, 36.
Middlesbrough, 26, 30.
Middlestone, 34.
Middleton (near Angerton) 14
Middleton (near Kyloe), 100.
Middleton (near Wooler), 13
Milkington, 91.
Miller, H., 73, 134, 146, 149.
Minsteracres, 5.
Mitford, 25, 56.
Monkridge, 10.
Monkwearmouth, 38.
Monument, Durham, 34.
Morpeth, 9, 25, 49, 50, 54, 56.
Murchison, Sir R. I., 39.
Murton Colliery, 37.

Netherton, 26.
Netherwitton, 66, 70.
Newbiggin-by-the-Sea, 18, 157.
Newbottle, 34.
Newcastle, 5, 26, 40, 44, 45, 47, 87, 108, 109, 122, 131, 168
Newham, 22, 88.
Newport, 26.
Newsham, 42, 152.
Newton (Cleveland), 145
Newton (Northumberland), 14.
Newton, E. T., 150.
Newton North Farm, 97
Newton, Old, 97.
Newton Underwood, 66
Nicholson, Prof. H. A., 63.
Norham, 155.
Norman, Dr., 183.
Normanby, 145.
North Shields, 35.
North Sunderland, 14, 64, 135.
North Tyne, 10, 13, 15, 17, 23, 61, 72, 89, 93, 95, 100, 136.
North Tynedale, 71.
Northumberland, *passim*.
Nunthorpe, 145.

Oakwood, 66, 70.
Old Newton, 97.
Orbigny, C. d', 126.
Ormesby, 145.
Otterburn, 10, 127, 128, 149, 156.
Ovingham, 56.
Oxford, 69, 70.

Papist's Cross, 68.
Peel Feel, 72, 147.
Pencil Mill, 82.
Penine Chain, 10, 65, 75, 100, 132.
Peppermoor, 97.
Persoon, —, 209.
Petersen, Dr. —, 103.
Philippi, Dr., 181.
Phillips, Prof. J. 61, 92
Pierce Bridge, 35.
Piper's Cross, 68.
Pittington, 37.
Pittington Hill, 34.
Plain Mellor, 27.

Plashetts, 8, 68, 70, 90, 130, 149.
Plessey, 49, 50.
Plough Rock, 88.
Pont, 14, 89.
Ponteland, 14.
Pontop, 48, 49.
Pow Burn, 79.
Prestwick Carr, 14.
Priory, Tynemouth, 33, 86.
Prudham, 62.

Quarrington Hill, 35, 37.

Raceby Hill, 137.
Rainton, 37.
Ramshope, 9.
Ramshope Burn, 10.
Ratcheugh, 97.
Raven Cleugh, 137.
Redcar, 142, 145, 158.
Redesdale, 5, 8, 152.
Redesmouth, 23.
Redewater, 9, 15, 72, 82, 149.
Redheugh, 13, 16, 134.
Redworth White House, 35
Riccarton, 82.
Ridlees, 105.
Ridpath, 136.
Ridsdale, 119, 121, 126, 128, 130, 149, 150, 151, 155, 156.
Robson, E., 208.
Robson, T. O., 134.
Rochester, 72
Rockcliff, 142.
Roddam Dene, 76.
Roker, 33
Roman Fell, 75, 76.
Roman Wall, 60, 61, 71, 93.
Roseberry Topping, 142, 145.
Rothbury, 25, 71-74, 77, 78, 81, 128, 131, 134.
Rothley Crag, 60.
Roxburghshire, 13.
Rubers Law, 107.
Rugley, 97.
Ryhope, 37, 43.
Ryton, 50, 51.

Saltburn, 142, 145.
Saltwick, 54.
Scot's Gap, 62.
Scotland, 3, 10, 13, 75, 77, 81, 82, 103, 107, 139, 140.
Scott, F., 208, 210.
Scremerston, 69, 123, 155, 156
Seaham Colliery, 37.
Seaham Harbour, 108.
Seaton Burn, 45.
Seaton Carew, 28, 31, 151.
Seaton Colliery, 37.
Seaton Delaval, 43.
Seaton Sluice, 44, 86, 133.
Sedgwick, Prof. A., 32, 33, 112.
Settlingstones, 136, 137.
Selby, J. P., 13.
Shaftoe Crag, 60.
Sharman, G., 150.
Sharperton, 79.
Shaw, G., 16.
Shawdon, 10.
Shepherd's Gap, 93, 94.
Sherburn Hill, 34, 37.
Shields, North, 35.
Shields, South, 12, 13, 32.
Shilbottle, 69, 70, 85, 88, 91.
Shilburnhaugh, 13, 68.
Shillmoor, 88.
Short Cleugh, 90.
Shotton, 37.
Silly Burn, 61.
Simonside Hills, 11, 71, 73, 147.
Simpson, J. B., 47.
Skelly Gate, 129.
Sladen, W. P., 119.
Slatyford, 87.

Smales, 130.
Smuggler's Cave, 36.
Soppit, 67.
South Shields, 12, 13, 32.
South Tyne, 10, 11, 15, 17, 25, 61, 89, 92.
SOUTHERN, J., 43.
Southwick, 37.
SPENCE, FARADAY, 208.
SPENCE, R., 136.
Spindlestone, 27, 100.
Spittleford, 97.
St. John Lee, 17.
St. Margaret's Farm, 97.
St. Mary's Haven, 97.
St. Mary's Island, 12, 44.
St. Oswald's Chapel, 61, 89.
Stag Rock, 99.
Stanhope, 20, 29, 99, 156.
Starslee, 68.
Stiddle Hill, 67.
Stillington, 31.
Stocksfield, 54, 60, 109.
Strawberry Hill, 34.
Stublick, 5, 51, 132.
Sunderland, 5, 36, 108, 109.
Sunderland, North, 14, 64.
Sweethope, 93.
Swinburne Mill, 93.
Swire, The, 7.

Tarret Burn, 90.
Tarset, 15.
TATE, G., 12-14, 22, 59, 60, 64, 69, 76, 88, 90, 97, 129, 147, 155, 202.
TATE, Dr. G. R., 198.
TATE, R., 145.
TEALL, J. H., 84, 86, 87, 90, 101-3, 105.
Team, 16, 25.
Tees, 26, 28, 29, 30, 31, 35, 80, 136, 140, 141, 155, 158, 189.
Teesdale, 5, 80, 82, 83, 92, 96, 107, 130, 135, 137.
Teesmouth, 12.
Teppermoor, Low, 93.
Thickley, 35.
Thickley, West, 35.
THOMPSON, J. (of Shawdon), 10.
Thorngrafton, 25.
THORNHILL, J., 208.
Thornley, 37, 49.
Till, 9, 15, 16.
TOPLEY, W., 25, 45, 62, 71, 74, 82, 92.
Tosson, 90.
Tottenham, 35.
TREVELYAN, Sir W. C., 62, 97, 155.
Trough End, 90.
Tunstall Hill, 32, 108.
Tweed, 21, 76, 77, 133.
Tweedmouth, 147.
Tyne, 4, 5, 10, 12, 13, 16, 17, 25, 37, 47, 48, 55, 57, 59, 60, 70, 71, 87, 151, 203.
Tyne, North, 10, 13, 15, 17, 23, 61, 72, 89, 93, 95, 100.
Tyne, South, 10, 11, 15, 17, 25, 61, 89, 92.
Tynedale, 5, 62.
Tynehead, 136.
Tynemouth, 12, 35, 36, 37, 86, 87, 158.
Tyneside, 135.

Upleatham, 145.
Upper Hall, 67.
Usway, 7.

Vale of York, 17.
VEITCH, Dr. W. Y., 14, 26.
VINE, G. R., 126.

Walbottle, 87.

Walker, 87, 109, 135.
Wall, 89.
Wall, Roman, 60, 61, 71, 93.
WALLACE, W., 137.
Wallsend, 16, 48.
Wanney Crags, 71.
Wansbeck, 10, 14, 15, 18, 25, 56, 60, 66, 71, 86, 88, 93, 136.
Ward's Hill, 96, 101.
Warden Hill, 15.
Warden Mill, 136.
Wark, 67, 70.
Wark's Burn, 89.
Warkworth, 55, 56.
Watling Street, 89.
WATSON, —, 204.
WAUGH, R., 208.
Wear, 10, 15, 25, 37, 49, 109, 151, 189.
Weardale, 5, 25, 62, 99, 130, 136, 137.
Well House, 37.
West Boldon, 34.
West Hartlepool, 14, 31, 32.
West Thickley, 35.
Westoe, 34, 37.
Westmorland, 107.
Wharnley, 89.
Whetstone House, 23.
Whickhope Burn, 13.
Whitburn, 12, 14, 19, 34, 87.
Whitburn Lizards, 19.
White Cross, 35.
White House, Redworth, 35.
Whitelaw, 106.
Whitelee, 82, 83, 106.
Whitley, 12, 35, 43.
Whittington, 62.
Whittington, Great, 67.
Whittonstall, 5, 50, 55, 109.
Whorlton, 87.
Whorlton-on-Tees, 156.
Widdrington, 52.
Wide Open, 45.
WILSON, R., 208.
WILSON, Dr. —, 13.
WINCH, N. J., 44, 46, 208-210.
Winter's Gibbet, 11.
Wolsington, 50.
WOOD, N., 26, 47, 51.
Woodburn, East, 23, 71.
Woodhorn, 52.
WOODWARD, Dr. S., 74.
Wooler, 13, 102, 185.
Wylam, 25, 50.
Wynyard, 31.

Yevering, 106.
York, Vale of, 17.
Yorkshire, 14, 28, 100, 136.

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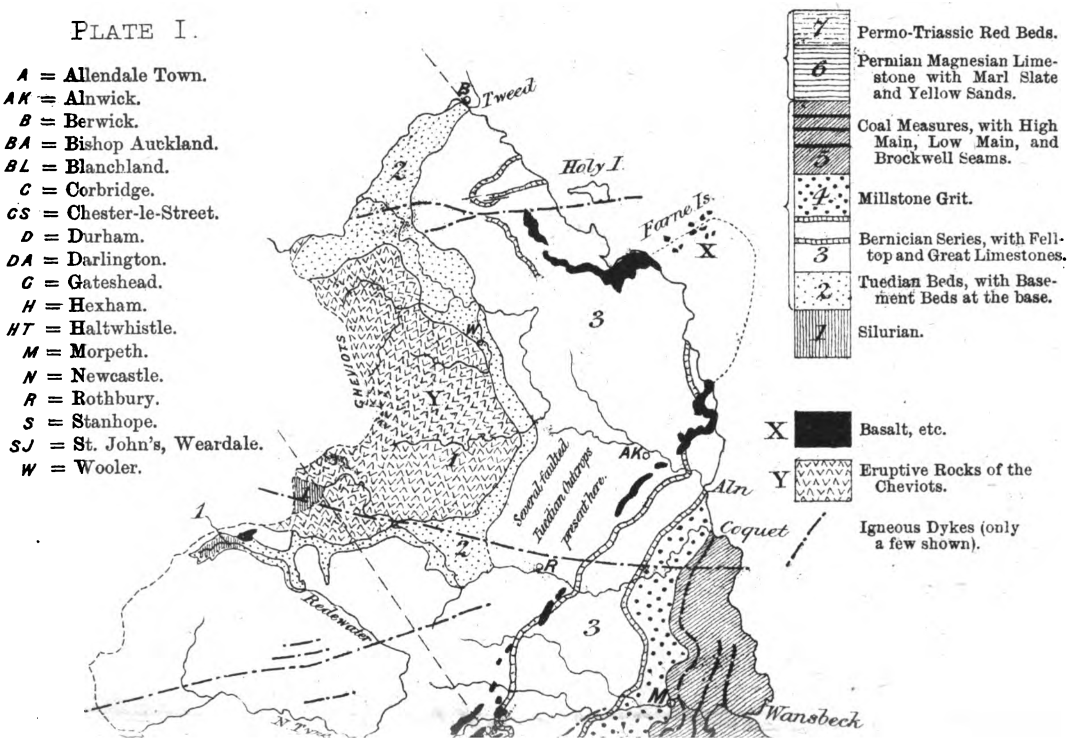
PLATE I.



A = Allendale Town.
AK = Alnwick.
B = Berwick.
BA = Bishop Auckland.
BL = Blanchland.
C = Corbridge.
CS = Chester-le-Street.
D = Durham.
DA = Darlington.
G = Gateshead.
H = Hexham.
HT = Haltwhistle.
M = Morpeth.
N = Newcastle.
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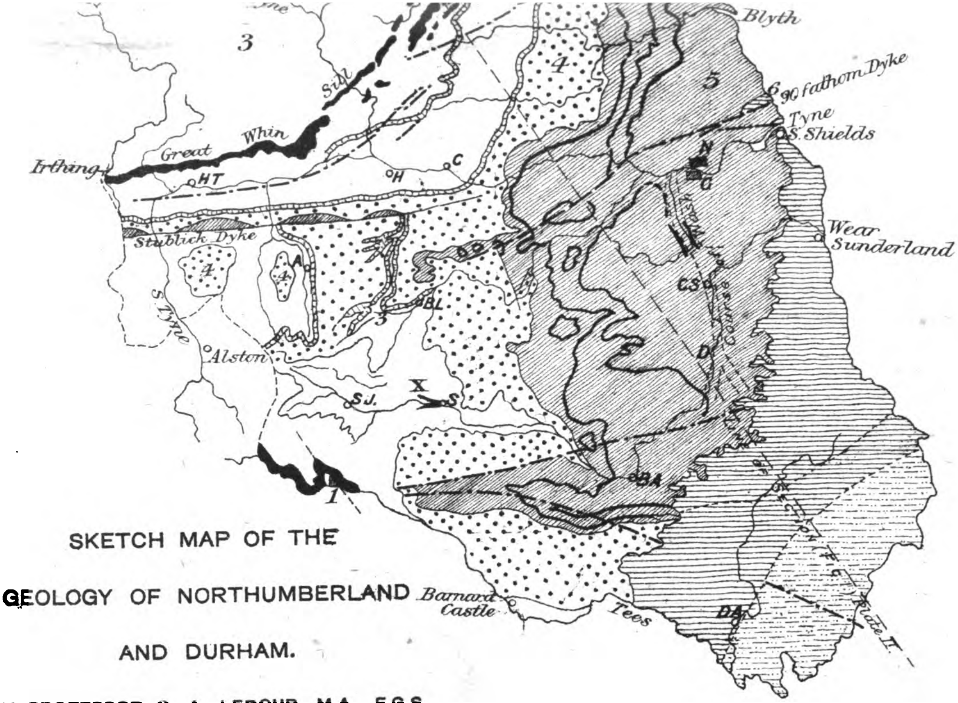
W = Wooler.

7 Permo-Triassic Red Beds.
6 Permian Magnesian Limestone with Marl Slate and Yellow Sands.
5 Coal Measures, with High Main, Low Main, and Brockwell Seams.
4 Millstone Grit.
3 Bernician Series, with Fell-top and Great Limestones.
2 Tuedian Beds, with Basement Beds at the base.
1 Silurian.
X Basalt, etc.
Y Eruptive Rocks of the Cheviots.
Igneous Dykes (only a few shown).
B
Tweed
Holy I.
Farne Is.
X
2
3
W
CHEVIOTS
Y
1
Several faulted Tuedian Outcrops present here.
AK
Aln
Coquet
R
2
1
Redewater
3
M
Wansbeck
N. Tyne



SKETCH MAP OF THE

GEOLOGY OF NORTHUMBERLAND

AND DURHAM.

BY PROFESSOR G. A. LEBOUR, M.A., F.G.S.

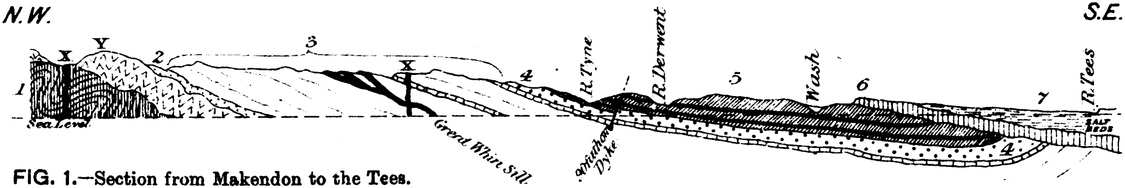


FIG. 1.—Section from Makendon to the Tees.
The horizontal scale and the letters and numbers are the same as in the Map, but the vertical scale is much exaggerated, and the dips are, therefore, higher than they are in nature.

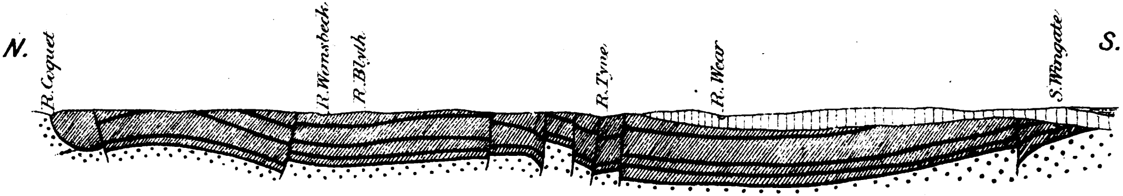


FIG. 2.—Section showing the lie of the Coal Measures from the Northern to the Southern extremity of the Great Northern Coal-field (after J. B. Simpson). Only the principal faults and some of the leading seams are shown.

PLATE III.

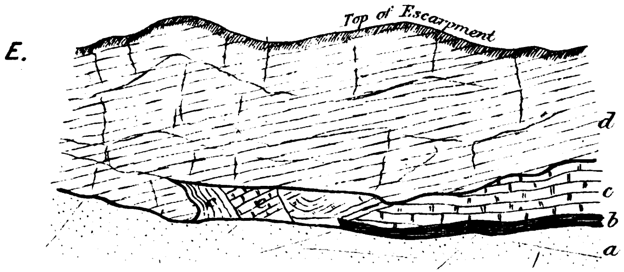


FIG. 1.—Section showing junction between the Yellow Sands and the overlying rocks as seen at Claxheugh, in 1884. *a.*=Yellow Sands. *b.*=Marl Slate. *c.*=Compact thinly-bedded Limestone. *d.*=Coarse massive irregularly bedded cellular Linestone. (*See* p. 36.)

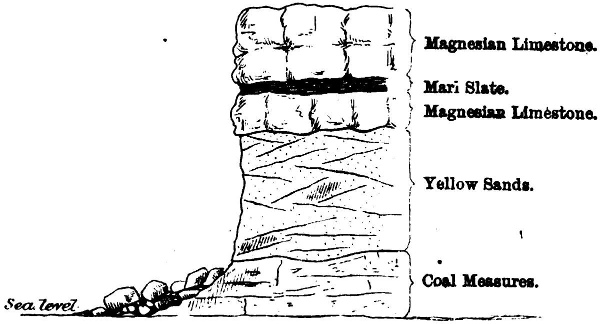


FIG. 2.—Permian Cliff at Tynemouth. *See* p. 36.)

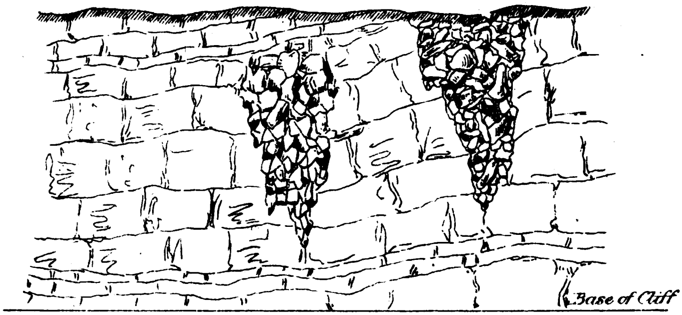


FIG. 3.—Breccia Gashes in the Permian Magnesian Limestone at Marsden Bay. (*See* p. 33.)

PLATE IV.

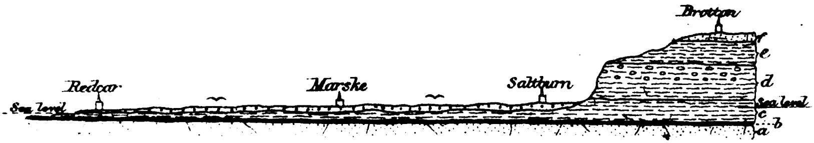


FIG. 1.—Section from the Mouth of the Tees to the Cleveland Hills along the coast. *a.*=Trias. *b.*=Rhætic. *c.*=Lower Lias. *d.*=Middle Lias, with Cleveland Ironstone. *e.*=Upper Lias, with Alum Shales and Jet. *f.*=Inferior Oolite. ⋎ = Blowing Sand and Drift.

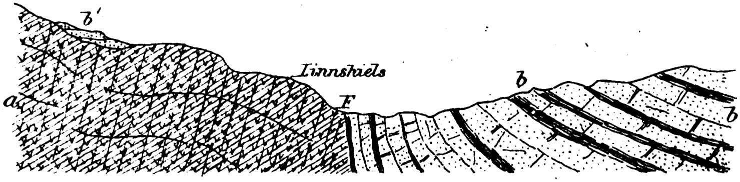


FIG. 2.—Section showing faulted boundary between the Cheviot Porphyrites (*a*) and the Tuedian Beds (*b*). *F.*=Fault. *b′.*=Outlier of Tuedian lying undisturbed on Porphyrites.

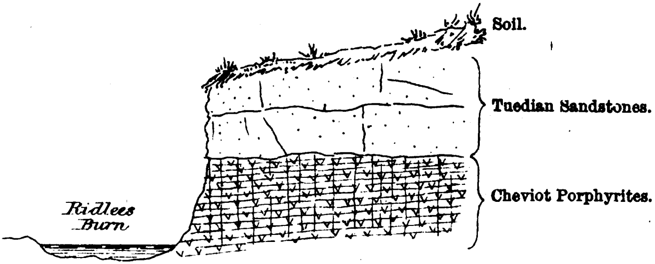
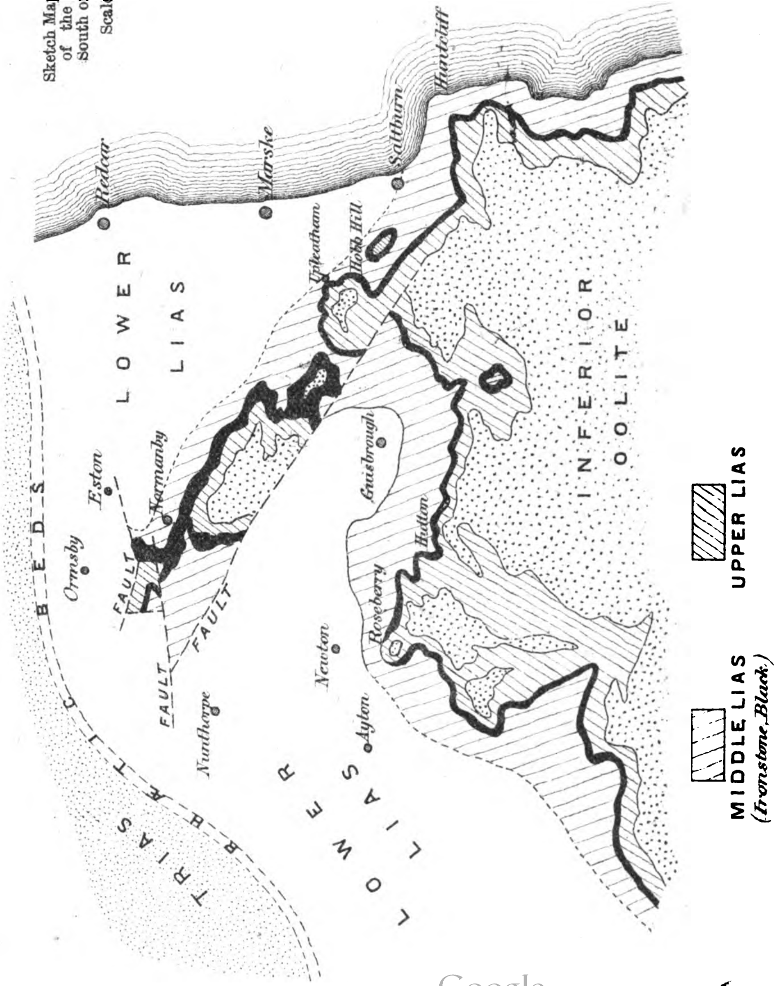


FIG. 3.—Section at the Ridlees showing unfaulted Junction between the Tuedian Beds and the Cheviot Porphyrites.

Sketch Map showing the Outcrop of the Cleveland Ironstone South of the Tees.

Scale: ⅜ in. = 1 mile.



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